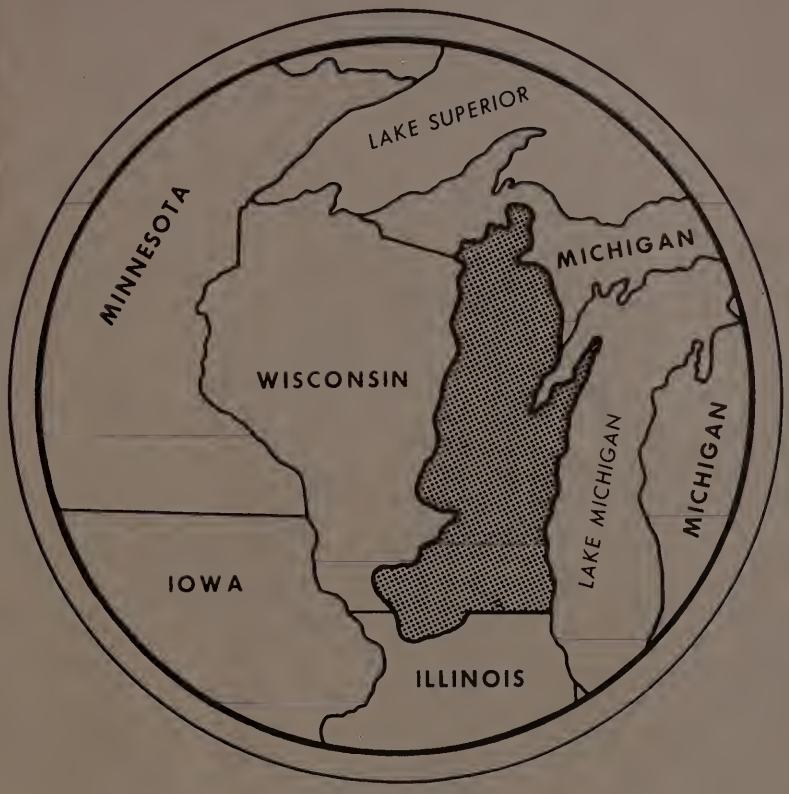
SUBJECT TO REVISION

EROSION AND SEDIMENTATION IN THE SOUTHEAST WISCONSIN RIVERS BASIN



REFERENCE REPORT NO. 9

WORKING MATERIALS FOR

SOUTHEAST WISCONSIN RIVERS BASIN

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

ECONOMIC RESEARCH SERVICE

FOREST SERVICE

USDA-SCS-LINCOLN, NEBR. 1970

EROSION AND SEDIMENTATION IN THE SOUTHEAST WISCONSIN RIVERS BASIN

R. N. Cheetham, Jr., Geologist, SCS

June 1973

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLES

TABLES (CONT'D)

TABLES (CONT'D)

ILLUSTRATIONS [1/]

List of Text Figures

1/ All photographs are U.S.D.A. Soil Conservation Service official photographs. Negatives are stored in the State Office. U.S.D.A. SCS, Madison, Wisconsin.

ILLUSTRATIONS (CONT'D)

ILLUSTRATIONS (CONT'D)

ABSTRACT

Channel erosion, streambank erosion, roadside erosion, and sediment accumulation in drainage channels are significant problems in more than sixty percent of the 39 counties in the Southeast Wisconsin Rivers Basin.

The deposition of 10 to more than 100 acres of infertile overwash occurs annually in 21 (54 percent) Basin counties.

Sheet erosion and urban erosion are significant problems in slightly more than one-third of the counties.

Wind erosion is a severe problem in 3 counties, and a moderate problem in 6 counties.

Slightly more than one-third of the counties report pond-capacity loss because of sedimentation or the accumulation of sediment in drainage channels. About 36 percent of the counties state that sedimentation was responsible for abnormally high nutrient levels in water bodies. More than fifty percent of the counties indicate sedimentation damage to the fish and wildlife resources.

Sediment yield from all land uses is greatest in the southern one-third of the Basin. This part of the Basin has the largest acreage of cropland and urban and built-up land. The northern one-third of the Basin, which has the largest acreage of forest and the smallest acreages of cropland and urban and built-up land, has less than one quarter the sediment yield of the south.

More than seven million acres of Basin soils are erosive. About 3.8 million acres of cropland, 611,000 acres of pasture, and 2.2 million acres of forest need erosion treatment measures.

Introduction

Erosion and the concomitant problem of sedimentation occur throughout the Southeast Wisconsin Rivers Basin. The principal variables are climate, geology, topography, plant cover, soils, land use, and the activities of man and animals. Excess water, as in storm runoff and floods, is an erosive and transporting medium for sediment.

Prior to the 1830's the Basin was essentially nonagricultural and the geologic cycle of weathering, erosion, transportation, and deposition had produced a slow but continuous change on the glaciated and nonglaciated landscape.

Between 1830 and 1860 there was limited agriculture and urbanization. From 1860 to the present we have had more than 100 years of farming, mining, logging, and increasing urbanization. As a result, culturally accelerated erosion and sedimentation has been superimposed on the geologic erosion, transportation and deposition processes. Certain national crises - the Civil War, World War I, and World War II, brought much land into production that was not suited for intense agriculture. During the 1930's erosion and sediment damage was coincident with depression, drought and dust. Since the 1930's,

Fig. 1. - SPRING RUNOFF FROM PLOWED FIELD
EROSION, POLLUTION AND SEDIMENTATION
BROWN COUNTY, WISCONSIN.

farmer assistance from state and federal agencies, better land utilization, improved technology, research, and legislation have combined to lessen erosion and sediment damages on agricultural lands. The formation of soil and water conservation districts was a most important step in assisting farmers, land owners, municipalities, and organized groups to conserve soil and water resources. On lands adjacent to and within expanding urban areas, erosion and sedimentation have frequently increased dramatically for short time periods.

In 1969, J. R. Thompson, Chairman of Work Group on Erosion and Sedimentation, Great Lakes Basin Framework Study, prepared a questionnaire and obtained responses from all Soil Conservation Service district conservationists within the study area.

> "The purpose of this questionnaire is to obtain information on erosion and sedimentation problems which is not otherwise available in published sources but can only be summarized from local knowledge, opinions, and impressions. The information generated from this source will provide an important input to the Great Lakes Basin Framework study. The questionnaire is designed to obtain impressions, approximations, and opinions by using mostly multiple choice questions. Opportunity is given to elaborate on details if precise information is readily available."

Because a part of the Southeast Wisconsin Rivers Basin is within the Upper Mississippi River Basin, additional questionnaires were sent out in 1971 by the Wisconsin geologist to district conservationists in Wisconsin and Illinois counties within the Rock River drainage area.

In Section I the responses are summarized by economic subareas and presented as tables to accompany the narrative. In Section II the responses are tabulated by state and county. The 11th question, an elaboration of additional information on erosion and sedimentation not covered by previous questions is reproduced verbatim by county. Additional data has been added to the questionnaire responses, to more fully explain the state of art - erosion and sedimentation in the Basin.

SECTION I

Location

The Southeast Wisconsin Rivers Basin lies in eastern and southern Wisconsin, north central Illinois, and the Upper Peninsula of Michigan. (See Figure 2, below). There are portions of two major continental drainage basins in the study area - the Upper Mississippi and the Great Lakes-St. Lawrence. Within the Southeast Wisconsin Rivers Basin, these two drainage basins have an area of about 15,469,807 acres or 24,171 square miles. This study is of the five economic subareas whose boundaries are not coincident with the hydrologic basin boundaries. (See Plate I, page 5).

FIGURE 2.
BASIN LOCATION MAP

Channel Erosion

This form of erosion is the removal of channel bed materials and downcutting of natural stream channels. Such erosion may initiate degradation of tributary channels causing damages similar to those from gully erosion and valley trenching. General usage addes to this form of erosion the degradation of livestock or logging tracks and trails.

U. S. DEPARTMENT OF AGRICULTURE

PLATE I

SOIL CONSERVATION SERVICE

LEGEND

BASIN BOUNDARY

STATE BOUNDARY

COUNTY BOUNDARY

ECONOMIC SUBAREA BOUNDARY

MICHIGAN

BARAGA

HOUGHTON

ONTONAGON

MARQUETTE

GOGEBIC

IRON

VILAS

DICKINSON

46°

FLORENCE

1

ONEIDA

FOREST

MARINETTE

MENOMINEE

BAY

LANGLADE

MENOMINEE

OCONTO

DOOR

MARATHON

WISCONSIN

SHAWANO

GREEN

KEWAUNEE

WOOD

PORTAGE

WAUPACA

2

OUTAGAMIE

BROWN

3

WAUSHARA

WINNEBAGO

CALUMET

MANITOWOC

MICHIGAN

ADAMS

SCALE 5 0 5 10 15 20 MILES 1/2,440,600

MARQUETTE

FOND DU LAC

SHEBOYGAN

GREEN LAKE

OZAUKEE

COLUMBIA

DODGE

WASHINGTON

LAKE

SAUK

90°

RICHLAND

4

IOWA

DANE

JEFFERSON

WAUKESHA

43°

MILWAUKEE

5

GRANT

RACINE

LAFAYETTE

GREEN

ROCK

WALWORTH

KENOSHA

ILLINOIS

JO DAVIESS

STEPHENSON

WINNEBAGO

BOONE

MC HENRY

LAKE

CARROLL

OGLE

SOUTHEAST WISCONSIN RIVERS BASIN

ILLINOIS, MICHIGAN, WISCONSIN

ECONOMIC SUBAREA MAP

U.S. DEPARTMENT OF AGRICULTURE

Economic Research Service, Forest Service, and Soil Conservation Service

SOURCE.
DRAWING NUMBER 5,R-26,353.9 AND INFORMATION FROM FIELD TECHNICIANS.

USDA-SCS-LINCOLN, NEBR.-1971

ALBERS EQUAL - AREA PROJECTION

3-20-73

5,R-26,353.20

TABLE 1 - Channel Erosion - Summary of Incidence and Principal Places of Occurrence.

Economic Subarea	Occurrence of Channel Erosion			Principal Place of Occurrence 1/		
	Rarely or Never	Occasionally to Often	Often to Very Frequently	Gully	Waterway	Track or Trail
1	1	5	0	0	0	4
2	2	8	1	1	4	6
3	0	4	2	0	2	1
4	2	4	1	0	2	3
5	0	5	4	1	5	4
BASIN TOTAL	5	26	8	2	13	18

1/ Fifteen counties did not respond and multiple responses were common.

Streambank Erosion

This is the removal of material from stream channel banks. It is caused by the force of flowing water and the caving of streambanks. Such erosion may damage bridges, buildings, or other structures and roads and highways. Fish and wildlife habitat may be damaged or obliterated.

Fig. 3 - STREAMBANK EROSION EAST BRANCH PECATONICA

IOWA COUNTY, WISCONSIN

The rates of streambank erosion are highly variable because of sediment types in bank profile, moisture, slope, vegetative cover, and variation in storm events. A three-year study on a pool and riffle stream in the northwest Lower Peninsula, Michigan by Hansen 1/, indicated that "the quantity of eroding bank sediments ranged from a high of 50,000 tons in 1967 to no measurable erosion in 1968." His Table 3 is reproduced below.

ANNUAL ERODING BANK CONTRIBUTION (IN TONS)

Water year	Total sediment load	Sediment load increase in study section	Eroding bank contribution
1967	70,000	57,000	50,000
1968	39,000	32,000	1/ 0
1969	48,000	38,000	20,000
TOTAL	157,000	127,000	70,000

On page 11, Hansen related erosion rates to moisture states and bank composition

Number of Banks	Soil Texture	Moisture Status	Erosion Rate Cubic Yards/ Bank/Year
7	Clay	Dry	27
17	Sand	Dry	57
15	Clay & Sand	Dry	88
9	Clay & Sand	Wet	207

As far as is known, there are no published studies of stream bank recession in the Basin.

During the development of Soil Conservation Service P.L. 566 watershed work plans in southwestern Wisconsin, streambank erosion studies were made above each structure site. From 25 to 50 percent of the stream net was traversed on foot and fairly detailed observations were recorded. Using channel dimensions, rate of lateral bank recession, and reaches of stream in feet, sediment volume was determined and a delivery rate applied. The examples below are taken from studies in Coon Creek Watershed, Vernon, Monroe, and La Crosse counties, Wisconsin.

1/ Hansen, Edward A., 1971. Sediment in a Michigan trout stream, its source, movement, and some effects on fish habitat. USDA Forest Serv. Res. Pap. NC-59, Illus. N. Cent. Forest Exp. Sta., St. Paul, Minn.

Site	Sq. Mi.	% Stream measured	AF Sediment delivered to Site
24	0.88	59.5	.015 AF per year
33	1.93	51.5	.016 AF per year

Horberg 1/ states that land forms and smaller erosional features by erosion are determined by:

(1) The structure of the underlying bedrock.
(2) The stage to which erosion has progressed.
(3) The relief available on the initial land surface.

As previously mentioned there are a number of additional and subtle variables, particularly the climatic cycle, soil profile, vegetation, and the influence of the nineteenth century agricultural man with European farming traits.

The frequency and degree of streambank erosion on larger county streams is given in Tables 2 and 3.

Table 2 - Frequency of Streambank Erosion on Larger County Streams

Economic Subarea	Occurs Rarely or Never	Occurs Occasionally to Often	Occurs Often to Very Frequently
Subarea 1	2	3	1 1/
Subarea 2	3	3	4 2/
Subarea 3	0	5	1 3/
Subarea 4	3	4	0
Subarea 5	0	3	7 4/
BASIN TOTAL	8	18	13

1/ Marinette County, Wisconsin
2/ Fond du Lac, Marquette, Waupaca and Winnebago
3/ Brown County, Wisconsin
4/ Stephenson and Winnebago counties, Illinois; and Dane, Dodge, Green, Iowa and Lafayette counties, Wisconsin

1/ Horberg, C.L., 1950, Bedrock Topography of Illinois: Bull. No. 73, 111. State Geol. Survey, 15 p.

TABLE 3 - Degree of Streambank Erosion [1/]

Economic Subarea	Occasional Scour	Frequent Scour	Occasional Eroded Channel Reaches	Frequent Eroded Reaches Of Channel
Subarea 1	4	1	0	1
Subarea 2	2	2	3	5
Subarea 3	2	1	2	1
Subarea 4	3	1	1	0
Subarea 5	1	1	3	4
BASIN TOTAL	11	6	9	11

[1/] Waupaca County, Wisconsin - Double Response
Racine County, Wisconsin - Double Response
Stephenson County, Illinois - Double Response
Rock County, Wisconsin - Double Response
Lafayette County, Wisconsin - Double Response

Streambank erosion by subarea and county occurs often to very frequently in:

Economic Subarea 1 - Marinette County, Wisconsin

Economic Subarea 2 - Fond du Lac, Marquette, Waupaca, and Winnebago counties, Wisconsin

Economic Subarea 3 - Brown County, Wisconsin

Economic Subarea 4 - None

Economic Subarea 5 - Stephenson and Winnebago counties, Illinois; and Dane, Dodge, Green, Iowa, and Lafayette counties, Wisconsin.

In 1969 a national assessment of streambank erosion was made for the Corps of Engineers, by the Soil Conservation Service. The streams were in watersheds with drainage areas less than 400 square miles.

The study area in Wisconsin was composed of drainage to Lakes Michigan and Superior and the Rock and Illinois rivers planning areas (Wisconsin portion only) of the Upper Mississippi River Basin.

Considered here is the Lake Michigan Basin Plan Area No. 2 which was subdivided into the Lake Michigan Northwest Planning Subarea 2.1, and Southwest Planning Subarea 2.2, the Rock, and the Illinois (Fox River).

The degree of erosion, bank miles of erosion, and bank miles of erosion considered moderate or severe because of physical or dollar damage are in tabular form.

TABLE 4 - Percent of Negligible, Moderate and Severe Streambank Erosion - 1969 Corps of Engineers Study

Basin Subarea	Negligible Bank Erosion	Moderate Bank Erosion	Severe Bank Erosion
Great Lakes 2.1	96%	3.5%	0.5%
Great Lakes 2.2	98%	1.5%	0.5%
Fox River (SEWRB)	92%	7.0%	1.0%
Rock River (SEWRB)	92%	6.5%	1.5%

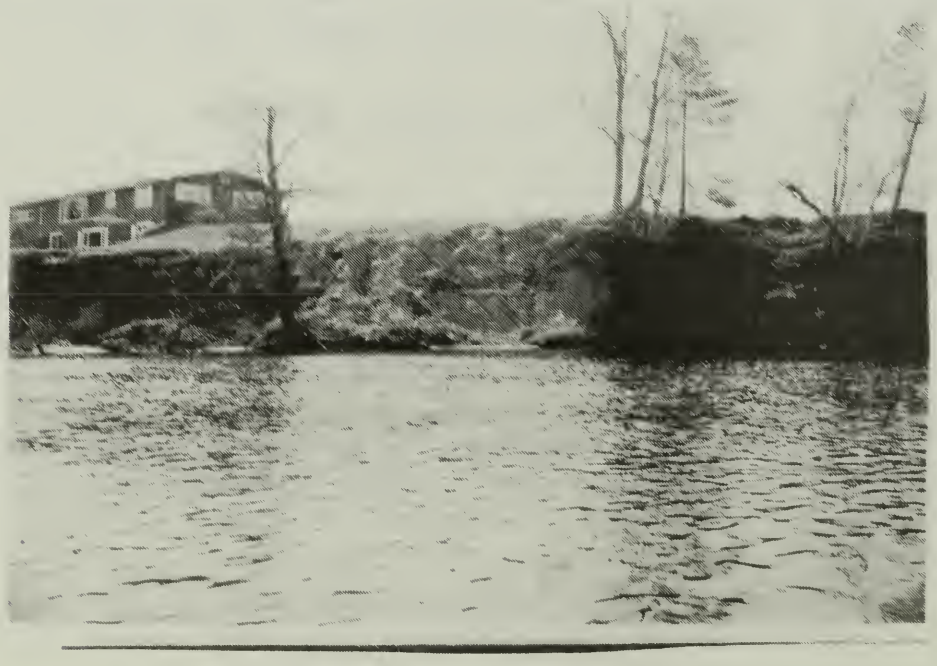


Fig. 4. - SEVERE BANK EROSION - WOLF RIVER SHAWANO COUNTY, WISCONSIN

TABLE 5 - Channel Lengths, Degree of Erosion, Amount of Erosion, and Damaged Bank Miles of Channel in Great Lakes Basin Commission and Upper Mississippi River Basin Portions of Basin.

Basin	Plan Area or Subarea	Length of Channels (Stream Miles)	Bank Miles with Moderate Erosion	Bank Miles with Severe Erosion	Bank Miles with Serious Physical Damage or High $ Damages
Great Lakes Basin	2.1	10,946	766.2	109.4	481.6
	2.2	1,137	34.1	10.6	26.5
Upper Miss. River Basin	Fox River (SEWRB)	889	124.4	17.8	78.2
	Rock River (SEWRB)	7,212	937.5	216.4	663.6
BASIN TOTALS		20,184	1,862.2	354.2	1,249.9

One hundred percent of the severly eroding streambanks, and twenty-five percent of the moderately eroding Basin streambanks should be protected. Based on these figures, the estimated amount of bank protection needed per economic subarea to the nearest 10 miles is as follows:

TABLE 6 - Bank Miles of Stream Needing Protection.

Economic Subarea	Bank Miles of Streambank Needing Protection
1	90
2	160
3	60
4	50
5	450
Total	810 Bank Miles

A more refined examination of the stream net was made by the Basin staff in 1972, using USGS topographic and planimetric maps. Random sections (about an eight percent sample per county) were measured for miles of perennial and intermittent stream. Sampling gave the following results:

TABLE 7 - Miles of Intermittent and Perennial Stream Based on Random Section Measurement.

Economic Subarea	Miles of Perennial Stream	Miles of Intermittent	Number of Sections Measured
1	3,926	561	428
2	4,120	3,236	569
3	1,071	1,560	250
4	1,504	1,392	222
5	4,568	5,054	459
Total	15,189	11,803	1,928

Ephemeral channels, which were not measured, would probably increase the figure to nearly 50,000 miles of defined stream channel in the Basin. Based on these figures, the amount of streambank needing protection is probably close to 1,100 bank miles on perennial and intermittent streams.

Detailed streambank erosion studies by the Soil Conservation Service in the Basin have been somewhat limited.

A 1970 survey on the Montello River, above Lake Montello, Marquette County, Wisconsin measured 2,080 feet of raw streambank. Estimated current sediment production was 10 tons per year. An estimate of streambank erosion for the remaining three miles to Harris Pond was 30 tons per year.

In 1971 studies were made for the Wolf River Streambank Stabilization Project (Lumberjack RC&D) near Shawano in Shawano County, Wisconsin. Twenty high value residential river lots have had severe

bank slides and streambank erosion. It was estimated that 1,035 cubic yards or about 1,210 tons of bank material (silt, sand, clay, and a trace of gravel), had eroded in the past five to ten years in a distance of 4,370 feet. See Figure 4, page 10.

The current cost of streambank stabilization on a Public Law 566 project is about $10 a linear foot. Costs per specific project under RC&D or other programs is highly variable and dependent on labor costs, design, maintenance, and riprap type and source.

The Holtwood Park Streambank Stabilization Project, Oconto County, Wisconsin will cost about $46,500 for 3,000 linear feet of stabilization. Banks will be sloped, mulched, and seeded and, in some places, sodded. The lower slope will be riprapped with a filter blanket. Tile drains are needed. Cost per linear foot will be about $15.50.

Some 500 linear feet of bank (one farm unit(will be stabilized along the Fox River in Green Lake County, Wisconsin. The estimated cost

Fig. 5. - RIPRAP AND FILTER BLANKET FOR EROSION CONTROL ON THE FOX RIVER GREEN LAKE COUNTY, WISCONSIN

per linear foot is $6.54. Major specific costs are $487 for 150 cubic yards of blasted limestone trucked a distance of eight miles. About 498 cubic yards of filter blanket $1618 and labor

for leveling and laying rock is $1,148. A dragline is needed for bank sloping.

Another project - 840 feet on the Fox River, Green Lake County, Wisconsin is estimated to cost $2.80 per linear foot. In this project fieldstone boulders from fence lines and boulder piles adjacent to the river will be used. The rock can be dumped after sloping a 5-foot bank. No filter or internal drains are to be used.

Roadside Erosion

Roadside erosion is a problem throughout the Basin. It occurs along town, county, and state roads. Damages include land voiding, sedimentation, deterioration of water quality, loss of wildlife habitat, and excess highway maintenance costs. Aesthetically, the landscape is marred. Highway safety is reduced when sediment is deposited on roads and hazard is further increased when county vehicles are removing sediment or performing maintenance work. Figure 6 shows urban erosion, and Figure 7 is rural erosion. Erosion control with a hydroseeder is shown on Figure 8.

Fig. 6. - URBAN ROADSIDE EROSION SHOWING HAZARD TO OTHER LAND USES, STEPHENSON COUNTY, ILLINOIS

TABLE 8. - Degree of Roadside Erosion in the Basin

Economic Subarea	Slight Problem	Moderate Problem	Severe Problem
Subarea 1	1	4	1
Subarea 2	4	6	1
Subarea 3*	1	5	2
Subarea 4	2	5	0
Subarea 5	1	8	0

*Calumet County, Wisconsin, made a triple response indicating that roadside erosion was slight in one-third of the county, moderate in one-third, and severe in one-third of the county.

A 1969 study, Erosion on Wisconsin Roadsides inventoried by county the acres, miles, and location of eroded areas over 100 square feet in size. The percent of erosion by kind of highway was given. No internal farm roads were studied. About 1,510 miles of roadside needed treatment.

Table 9. - Summary of Roadside Erosion in Wisconsin - 1969.

Economic Subarea	Total Erosion Miles	Percent of Erosion by Road Type		
		Town	County	State
Subarea 1	290	50%	49%	1%
Subarea 2	370	62%	37%	1%
Subarea 3	340	80%	19%	1%
Subarea 4	190	62%	32%	6%
Subarea 5	320	71%	27%	2%

About three-fourths (73 percent) of the eroded areas in Wisconsin occur along town roads. About one-fourth (24 percent) of the erosion is along county roads. Three percent of the erosion is on state highways.

Fig. 7. -ROADSIDE EROSION, STATE HIGHWAY 135
KIDDER SOILS UNDERLAIN BY TILL
JEFFERSON COUNTY, WISCONSIN

Fig. 8. - HYDROSEEDER SPRAYING WATER, SEED AND FERTILIZER ON ROADCUT MANITOWOC COUNTY, WISCONSIN

A more detailed tabular presentation by economic subarea shows roadside erosion in square feet and the rank of the county as far as total erosion. The rank of 1 indicates the greatest amount of erosion and 72 the least amount of roadside erosion for the 72 Wisconsin counties.

TABLE 10. - County Roadside Erosion in Wisconsin - Square Feet and Rank in State - 1969.

Economic Subarea	County	Roadside Erosion (Square Feet)	Rank in Wisconsin (72 Counties in Study) 1/
1	Forest	518,000	68
	Florence	1,316,000	62
	Marinette	3,575,000	28
2	Langlade	3,254,000	34
	Oconto	3,057,000	38
	Menominee	32,000	71
	Shawano	924,000	64
	Waupaca	917,000	65
	Outagamie	1,459,000	60
	Waushara	2,659,000	45
	Winnebago	2,516,000	47
	Marquette	886,000	66
	Green Lake	2,804,000	43
	Fond du Lac	12,339,000	5
3	Door	2,454,000	48
	Brown	5,477,000	16
	Kewaunee	3,209,000	36
	Calumet	2,305,000	50
	Manitowoc	8,352,000	7
	Sheboygan	2,291,000	51
4	Washington	3,240,000	35
	Ozaukee	749,000	67
	Waukesha	4,369,000	18
	Milwaukee	--	72
	Walworth	2,041,000	59
	Racine	2,788,000	44
	Kenosha	114,000	70
5	Dodge	6,462,000	12
	Iowa	2,381,000	49
	Dane	2,825,000	42
	Jefferson	488,000	69
	Lafayette	3,806,000	25
	Green	4,070,000	22
	Rock	2,221,000	53

1/ There are seventy-two counties in the State of Wisconsin - thirty four of which are in the economic subareas of the Southeast Wisconsin Rivers Basin.

It is difficult to separate the cost of sediment removal from roads and ditches since this item has never been separable from annual and normal highway maintenance. It is probably much less than one percent of normal annual maintenance cost. 1/

Nevertheless, some idea of erosion control costs are available based on a table for Average Contract Unit Prices for Highway Construction from 1968 through 1971 issued by Division of Highways, Department of Transportation, State of Wisconsin.

TABLE 11. - Average Contract Dollar/Unit Prices - Highway Construction - Wisconsin

Item	Unit	1968	1969	1970	1971
Common Excavation	Cu. Yd.	0.45	0.51	0.51	0.54
Rock Excavation	Cu. Yd.	0.95	0.69	0.78	1.35
Mortar Rubble Ditch Checks	Cu. Yd.	60.00	-	-	-
Catch Basin	Each	353.12	365.12	421.85	429.17
Mulching	Sq. Yd.	0.06	0.07	0.07	0.07
Erosion Mat	Sq. Yd.	0.62	0.67	0.71	0.73
Fertilizer	Cwt.	6.72	6.96	7.79	9.38
Seeding	Sq. Yd.	0.03	0.03	0.04	0.04
Seeding	Lb.	-	1.58	1.85	1.77
Sodding	Sq. Yd.	0.79	0.91	1.07	1.20
Concrete Ditch Checks	Cu. Yd.	65.00	66.50	-	-

Urban Erosion

Urban erosion is a general term, but it is predominantly sheet and rill erosion from home sites, apartments, office buildings, shopping centers, or industrial complexes. In large plats of urbanizing land, the flow lines become channelized and these new ephemeral drainage ways are subject to bank erosion, and channel cut or fill. Roads built in conjunction with new developments are subject to bank erosion. Road drainage ditches may degrade.

Figures 9 and 10 illustrate erosion and sedimentation in urban developments and industrial park areas - formerly agricultural land.

1/ Information supplied by Mr. George Jenson, Assistant Chief Maintenance Engineer, Division of Highways, Transportation Department, State of Wisconsin.

Fig. 9. - CURB AND GUTTER UNDERCUT BY EROSION
IN OZAUKEE SILT LOAM
WASHINGTON COUNTY, WISCONSIN

Fig. 10. - EROSION AND SEDIMENTATION
INDUSTRIAL PARK WATERWAY
WAUKESHA COUNTY, WISCONSIN

Based on questionnaire results the significance and qualitative amount of urban erosion is shown on Table 12.

TABLE 12. - Significance and Qualitative Amount of County Urban Erosion.

Economic Subarea	Significant Problem		Amount of Erosion from Urban Areas		
	Yes	No	Negligible To Small	Small to Large	Large to Very Large
Subarea 1	0	6	6	0	0
Subarea 2	3	8	9	2	0
Subarea 3	3	3	4	1	1
Subarea 4	4	3	2	4	1
Subarea 5	4	5	4	4	1

The location of urban developments is mostly on nearly level or sloping land.

TABLE 13. - Location of Current Urban Developments

Economic Subarea	On Nearly Level Land	Sloping Land	Very Sloping to Steep Land
Subarea 1	3	3	0
Subarea 2	7	4	0
Subarea 3	3	2	Kewaunee County
Subarea 4	3	3	Walworth County
Subarea 5	2	7	0
TOTAL	18	19	2

Most land lost to agriculture per county is from 10 to 50 acres. Table 14 indicates the range of land gained by urban expansion.

TABLE 14. - Estimated Transition of Agricultural Land to Urban Use in the Basin Per Year.

Economic Subarea	Less than 10 Acres	10-50 Acres	50-100 Acres	100-500 Acres	500 Acres or More
1	1	4	1	0	0
2	3	3	2	2	1
3	0	1	3	2	0
4	0	0	1	3	3
5	0	3	1	2	3
TOTAL	4	11	8	9	7

Large acreages of land in transition to urban use are associated with the standard metropolitan statistical area districts of Green Bay, Brown County, Wisconsin, Economic Subarea 3; Milwaukee, Milwaukee County, Wisconsin, Economic Subarea 4; and Madison, Dane County, Wisconsin, Economic Subarea 5.

No measurements have been made in the Basin for rates of urban erosion. The Great Lakes Basin Framework Study 1/ has developed from field measurements and equation - an erosion rate from construction activities in each major metropolitan complex. The only applicable figures are:

Metropolitan Complex	Construction Site Percent Denuded Cover	Average Annual Soil Loss Tons/Ac/Yr
Green Bay-Oshkosh	100	90
Milwaukee	100	125

The soil loss figures would seem more realistic if the percent of denuded cover at a construction site were reduced to 85 percent. This would give the following soil losses:

Green Bay-Oshkosh - 75+ tons per acre per year
Milwaukee - 106+ tons per acre per year

Critical Area Treatment - Eroding Lands

One of the current U.S.D.A., SCS Resource Conservation Development (RC&D) programs is critical area treatment of eroding lands. This is accomplished primarily by diverting water, resloping, and vegetative practices. Roadside erosion control through RC&D assistance is noted on the following page.

1/ Great Lakes Basin Framework Study, 1971, Appendix 18, Erosion and sedimentation, Section 6. erosion from urban development in the major metropolitan complexes, 18-114 to 125.

TABLE 15. - Roadside Erosion Control in Michigan and Wisconsin through RC&D Assistance.

State	County	Miles Eroding	Miles to be Treated
Michigan	Menominee	40	28
	Dickinson	48	35
	Iron	56	42
Wisconsin	Forest	12	5
	Florence	21	11
	Langlade	27	11
	Marinette	43	17
	Marquette	14	8
	Menominee	1	0.5
	Oconto	72	36
	Shawano	21	8
	Waupaca	20	10
	Waushara	34	17
TOTAL		409 Miles	217.5 Miles

The treatment of surface mined areas is estimated to be 1,575 acres in the next 10 to 15 years - out of 5,262 acres inventoried, in Economic Subareas 1 and 2.

TABLE 16. - Surface Mined Acres, and Acres to be Treated through RC&D Assistance.

State	County	Acres Disturbed	Acres to be Treated 10-15 Year Period
Michigan	Menominee	185	100
	Dickinson	80	80
	Iron	5500	225
Wisconsin	Forest	53	5
	Florence	184	28
	Langlade	55	11
	Marinette	1515	379
	Marquette	160	48
	Menominee	50	5
	Oconto	1000	250
	Shawano	650	195
	Waupaca	750	225
	Waushara	80	24
TOTAL		5262	1575

Surface mined areas such as inactive gravel pits and borrow areas produce sediment and are eyesores. The Lumberjack and the Golden Sands (Wisconsin RC&D projects) will provide technical and financial assistance for treating these areas. At the present time the mine dumps in the Rock River Subarea 5 area are a rather conspicuous landscape feature, and little remedial work has been done. See Figures 11 and 12.

Fig. 11. - MINE WASTE ADJACENT TO INTERMITTENT STREAM NEAR SHULLSBURG, LAFAYETTE COUNTY, WISCONSIN

Fig. 12. - MINE DUMP -ABANDONED LEAD MINE
NEAR SHULLSBURG
LAFAYETTE COUNTY, WISCONSIN

Wind Erosion

Wind erosion is the detachment and transportation of mineral and/or organic soil particles by the wind. The amount of soil transported or blown varies with particle size-grade, weight of particle, moisture of soil, surface roughness, crop residue, wind velocity, area of open level land, and other factors.

Damages from wind erosion include loss of top soil, reduction of soil productivity, the abrasion or cutting of crop stems and roots and the filling of channel and roadside ditches. Active sand dunes may form, and coarse sand and gravel may remain as a lag concentrate. Local dust storms create health and safety hazards.

As far as is known, there are no natural measured wind erosion statistics for the Southeast Wisconsin Rivers Basin.

The degree of wind erosion in the Basin was categorized in the questionnaire as negligible, slight, moderate, or severe problem. Table 14 summarizes the extent of the problem.

TABLE 17. - Degree of Wind Erosion by County and Economic Subarea

Economic Subarea	Negligible Problem	Slight Problem	Moderate Problem	Severe Problem
Subarea 1	2	3	1	0
Subarea 2	2	3	3	3
Subarea 3	2	3	1	0
Subarea 4	2	5	0	0
Subarea 5	3	5	1	0
TOTAL	11	19	6	3

Figure 13 shows fixed sand dunes with plant cover destroyed. This will cause deflation and sand dune movement.

Fig. 13 - DUNE AREA WITH PLANT COVER DESTROYED BY POWER BIKES, MOTORCYCLES AND DUNE BUGGIES NEAR LAKE MICHIGAN, KENOSHA COUNTY, WISCONSIN

Fig. 14 - BLOWOUT AROUND REMAINS OF OLD FIELDSTONE BUILDING
MARQUETTE COUNTY, WISCONSIN

Significant wind erosion damage occurs by deflation of mineral and organic soils and occasionally by dune blow.

TABLE 18. - Significant Wind Erosion Damage on Soils, Sand Dunes, and Mine Waste.

Economic Subarea	Mineral Soils	Organic Soils	Sand Dunes	Mine Waste
1 1/	4	0	0	0
2 2/	8	4	1	0
3 3/	4	2	2	0
4 4/	3	6	0	0
5 5/	6	2	0	0
TOTAL	25	14	3	0

1/ No response - Forest and Florence counties, Wisconsin.

2/ No response - Menominee and Winnebago counties, Wisconsin.
Multiple response - Oconto, Outagamie, Waushara and Marquette counties, Wisconsin.

3/ Multiple response - Kewaunee and Sheboygan counties, Wisconsin.

4/ No response - Milwaukee County, Wisconsin.
Multiple response - remaining six Wisconsin counties.

5/ No response - Lafayette County, Wisconsin - "not considered a significant problem."

Based on a 30-year average wind speed and a 30-year average rainfall record, a special study in central Wisconsin 1/

"indicated two critical periods for potential wind erosion in Wisconsin. One is in October and November when precipitation is low and wind movement relatively high and the other is in March, April, and May when precipitation is fairly good but wind movement is considerably higher than during other parts of the year. Since field preparation and planting is underway during April and May, fields are bare and in a highly erodible condition and this would appear to be the most critical period for wind erosion in Wisconsin."

Using a portable wind tunnel, numerous field sites in central Wisconsin were tested for wind tunnel erodibility on loamy sands, mucky peat, and a loamy fine sand. Results vary with conditions of soil structure, surface roughness, crop residue, and other factors. The wind tunnel measurements were adjusted to a 40 rod field length based on measured natural Ohio wind erosion and a predicted value was established from calculations from a wind erosion equation. Plate II, page 29 compares measured wind tunnel soil losses with those predicted by the equation. Conclusions from their research were that the equation can be used with judgment to design wind erosion control practices on the sands in central Wisconsin. However, it seriously underestimated the erosion potential of muck soils and probably should not be used on these soils.

1/ Woodruff, N.P., et. al., 1969, A Study of Wind Erosion in Wisconsin, p. 30.

PLATE II. - Comparison of Measured Wind Tunnel Soil Losses with Losses Estimated by Wind Erosion Equation 1

Location	Wisconsin County	Surface Condition	Soil Type	Residue	Soil Loss	
					Wind Tunnel Adjusted 1/	Calculated from Equation 2/
				Lbs./A	Tons/A./Yr.	Tons/A./Yr.
Hancock Station	Waushara	Plowed, planted to corn, raked	Plainfield loamy sand	0	17.0	35.0
Hancock Station	Waushara	Plowed, planted to corn, crusted	Plainfield loamy sand	0	22.0	34.0
Hancock Station	Waushara	Cornstalk field planted, no tillage	Plainfield loamy sand	1,668	7.5	27.0
Hancock Station	Waushara	Disked, winter-killed oats	Plainfield loamy sand	522	2.7	13.0
Hancock Station	Waushara	Chemically killed rye and wheat	Plainfield loamy sand	837	0	3.5
Hancock Station	Waushara	Plowed and disked winter-killed cats	Plainfield loamy sand	0	0	6.0
Haviland Muck Farm	Portage	Plowed, disked for potatoes	Houghton mucky peat	0	12.2	2.0
Erickson Farm	Waushara	Planted to corn, no tillage	Richford loamy sand	0	14.5	11.0
Radcliffe Farm	LaCrosse	Disked twice, planted to corn	Plainfield loamy find sand	795	10.5	9.0
Radcliffe Farm	LaCrosse	Disked twice, planted to corn	Boone-Hixton loamy sand	1,329	18.5	19.5

Source: Woodruff, N.P., et. al., 1969, A Study of Wind Erosion in Central Wisconsin, p. 24, Table 3

1/ Adjusted to 40 rod field length based on natural erosion measured in Ohio

2/ Based on field length of 40 rods and climatic factor, C', = 18.

Sheet Erosion

Sheet erosion is the detachment of soil particles by raindrop impact or snow melt and removal by overland flow. Damage is caused by soil loss and the reduction of soil productivity. Rill erosion, in which very small channels appear on cultivated land, is considered an aspect of sheet erosion.

As a preface to the discussion on sheet erosion, mention should be made of soil capability classifications which "are one of a number of groupings made primarily for agricultural purposes." 1/

The capability grouping of Basin soils is designated by Roman numerals I through VIII. Class I through IV soils are the most commonly cultivated. Class I soils are those with few limitations that restrict their use. As the numerals increase, there are limitations that reduce the choice of plants and dictate more intensive conservation practices. Class V through VII soils are generally not suited for cropping because of miscellaneous hazards such as flooding (V), topographic configuration, rock outcrops, and thin soil profile. Class V through Class VII soils are mostly pasture, woodland, or wildlife area.

Specific soil limitations such as risk of erosion (e), droughtiness, stony or steep (s), or excess water (w) are shown as subclass lower case letter added to the capability class. Within the subclasses are capability units 1, 2 and so on, that combine like soils into units or groups suitable for a particular cropping pattern and management practice.

The distribution of soils by capability group and hazard is detailed in tabular data obtained from soil and water conservation needs inventories for the states of Illinois, Michigan and Wisconsin.

1/ Klingebiel, A.A., and Montgomery P.H., 1961, Land Capability Classification, Soil Conservation Service, U.S.D.A., Agricultural Handbook no. 210, p. 1.

TABLE 19. - Percent Distribution-Class I-VIII Soils and Hazards

Economic Subarea	Class I Soils	Class II through VIII Soils		
		e Soils (Erosive)	s Soils (Steep,) (Stony,) (Droughty)	w Soils (Wetness) (Flooding)
Subarea 1	<1%	45%	21%	34%
Subarea 2	1%	43%	23%	33%
Subarea 3	1%	57%	8%	34%
Subarea 4	8%	41%	14%	37%
Subarea 5	1%	64%	15%	20%

Table 20 indicates the distribution by economic subarea and land use of Class I soils or those soils with few limitations that restrict their use.

TABLE 20. - Distribution of Class I Soils by Subarea and Land Use. 1/

Economic Subarea	Percent of Total Subarea Acres	Cropland Acres	Pasture Acres	Forest Acres	Other Land Acres
Subarea 1	1%	2,400	-	900	200
Subarea 2	1%	31,000	200	3,900	900
Subarea 3	1%	6,100	600	1,200	300
Subarea 4	8%	94,800	1,100	3,500	5,200
Subarea 5	1%	244,000	21,500	12,500	15,100
TOTAL		378,300	23,400	22,000	21,700

Distribution of the erosive soils by land use and subarea are noted below.

TABLE 21. - Distribution of Erosive (e) Soils by Subarea and Land Use.

Economic Subarea	Percent of Total Subarea Acres	Cropland Acres	Pasture Acres	Forest Acres	Other Land Acres
Subarea 1	45%	198,000	24,000	1,129,000	23,000
Subarea 2	43%	957,000	88,000	706,000	73,000
Subarea 3	57%	707,000	40,000	112,000	55,000
Subarea 4	40%	381,000	33,000	52,000	56,000
Subarea 5	64%	1,831,000	277,000	214,000	118,000
TOTAL		4,074,000	462,000	2,213,000	325,000

1/ All figures have been rounded to 00 or 000.

TABLE 22. - Distribution of Erosive (e) Soils by Economic Subarea. 1/

Subarea	IIe Acres	IIIe Acres	IVe Acres	VIe Acres	VIIe Acres
Subarea 1	633,000	416,000	178,000	100,000	47,000
Subarea 2	911,000	435,000	277,000	118,000	82,000
Subarea 3	601,000	202,000	56,000	35,000	20,000
Subarea 4	675,000	105,000	56,000	34,000	7,000
Subarea 5	1,129,000	647,000	464,000	156,000	43,000
TOTAL	3,949,000	1,805,000	1,031,000	443,000	199,000

1/ Rounded to 000

County responses to the 1969 and 1971 questionnaires on erosion and sedimentation are summarized by economic subarea.

TABLE 23. - Unusual Sheet Erosion Problems and Causes by Economic Subarea.

Economic Subarea	County Areas with Unusual Sheet Erosion		Areas Exist Because of Local				
			Soil Class	Farming			
	Yes	No	Management	Topography	Practice	Feedlots	Other
Subarea 1	0	6	-	-	-	-	-
Subarea 2	4	7	-	1	3	-	2
Subarea 3	3	3	-	3	2	-	1
Subarea 4	3	4	-	3	4	-	4
Subarea 5	7	2	-	1	6	2	3
TOTAL	17	22	0	8	15	2	10

Specific comments from Soil Conservation Service district conservationists in regards to unusual sheet erosion were:

"Canning companies lease land, and this heavy cash crop has no control measures or grass crop in rotation."
"No residue or cover left after pea or sweet corn harvest."
"Fall plowing."
"Continuous row crop on land owned by speculators waiting to 'develop' this land."
"Clean tillage practice allowed under feed grain program."
"Hog lots on steep slopes."
"Beef operations - overpopulation."

To determine sheet erosion soil losses and sediment storage requirements for floodwater retarding structures in the small watersheds program (P.L. 566), 83rd Congress, it was necessary to compute sheet erosion by some regional and empirical method. From 1956 to 1972, Wisconsin sediment storage requirements for P.L. 566 structures were determined by a modified Musgrave formula suitable for the "Cornbelt Area." 1/

Soil type, capability class, subclass, unit, percent of slope and length of slope, erodibility and rainfall were used to obtain soil factor and slope factor. Rotation and management were used to obtain a cropping pattern factor. Acres of a particular class, such as IIel were multiplied by a soil factor, cropping pattern factor, and slope factor to obtain soil loss in acre inches per year. Acre inches were converted to acre feet, then to tons, and finally to tons per acre per year.

Examples of data and predicted soil losses in tons per acre per year are given for Waupaca County subarea 2. Calumet County subarea 3 and Lafayette County subarea 5. Data was obtained from farm units in each Soil and Water Conservation District (SWCD). In Wisconsin a county is one district. Land owners may or may not be cooperators with their SWCD. Detailed studies up until 1972 by the Soil Conservation Service in the Southeast Wisconsin Rivers Basin had been limited to selected farm units in Langlade and Waupaca counties in subarea 2, Calumet County in subarea 3, and Dane, Green, Lafayette, and Iowa counties in subarea 5. No studies had been made in subareas 1 and 4.

1/ Musgrave, G.W., 1947, The quantitative evaluation of factors in water erosion - a first approximation: Jour. Soil and Water Conservation, v. 2, p. 133-138.

Ghormley, G.E., 1956, Allocation of sediment storage for design of floodwater retarding structures (Eng. Memo. No. 9); mimeographed memorandum, U.S. Department of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin, p. 4.

Thorp, E.M., 1967, Elements of erosion and sedimentation, a training guide prepared for SCS engineers and geologists; mimeographed separate U.S. Department of Agriculture, Midwest RTSC, SCS-EWP Unit, Lincoln, Nebraska, p. 14.

TABLE 24. - Estimated Cropland Soil Losses from Erosive (e) Soils, 16 SWCD Cooperator Farms, Waupaca County, Wisconsin, Economic Subarea 2.

Capability Unit	Cropping Pattern	Practice	Slope		Soil Loss Tons/Acre Per Year
			%	Length Feet	
IIe1	R02H	Contour-T	4	100	0.85
	R03H	CSC	4	150	0.76
	R03H	CSC	5	100	0.80
	R03H	X-slope	4	50	1.19
	R03H	X-slope	2	100	0.70
	R03H	Terracing	4	200	0.90
	RR03H	X-slope	4	200	5.80
IIe6	R02H	X-slope	4	150	3.34
	R04H	X-slope	7	100	3.29
	RR03H	X-slope	3	150	3.34
IIIe7	R03H	X-slope	4	200	2.81
	R03H	Terraced	4	200	0.92
	R Cont.	X-slope	2	80	6.53
	R03H	X-slope	4	50	1.22
IIIe1	5H	Cross Slope	8	100	0.80
	R02H	Contour-T	8	100	3.29
	RR03H	X-slope	7	100	8.18
	R03H	CSC	10	150	2.60
IIIe4	R02H	X-slope	2	100	1.00
IIIe6	R03H	Terraced	9	100	1.77
IIIe7	R02H	X-slope	7	150	7.28

TABLE 25. - Estimated Cropland Soil Losses Erosive (e) Soils, Site 8, First Capitol Watershed, Lafayette County, Wisconsin, Economic Subarea 5.

Capability Unit	Cropping Pattern	Practice	Slope		Soil Loss Tons/Acre Per Year
			%	Length Feet	
IIe1	R02H	None	4	350	7.72
	R02H	X-slope	4	350	5.47
	R02H	CSC	4	350	1.80
	R04H	CSC	4	350	1.09
	RR02H	X-slope	4	350	10.11
	RR02H	CSC	4	350	3.39
	RR03H	X-slope	4	350	8.15
	RR03H	CSC	4	350	2.73
	RR04H	X-slope	4	350	6.89
IIe2	R02H	X-slope	4.5	350	6.43
	RR03H	CSC	4.5	350	3.21
IIIe2	R02H	X-slope	7	300	10.61
	R02H	CSC	7	300	3.50
	R04H	CSC	7	300	2.12
	RR02H	X-slope	7	300	19.62
IVe1	R02H	X-slope	8	275	12.07
	R02H	CSC	8	275	3.98

TABLE 26. - Estimated Cropland Soil Losses Erosive (e) Soils, Site 1, Brillion Watershed, Calumet County, Wisconsin, Economic Subarea 3.

Capability Unit	Cropping Pattern	Practice	Slope		Soil Loss Tons/Acre Per Year
			%	Length Feet	
IIe1	R03H	Contour	3	150	1.02
	RR03H	X-slope	3	150	3.31
	RR03H	CSC	3	150	1.11
IIe6a	R Cont.	X-slope	2	150	12.85
	R02H	X-slope	3	150	2.22
	R03H	X-slope	3	150	1.55
	RR03H	X-slope	3	150	3.31
	RR03H	Contour	3	150	2.20
IIIe1	RR03H	X-slope	7	200	12.40
	RR03H	CSC	7	200	4.16
	04H	X-slope	7	200	1.25
IVe1	R03H	X-slope	12	150	11.46
VIe1	RR03H	X-slope	20	100	39.87

Erosion in Woodland and Forest

In Wisconsin soil losses from forest and woodland were first measured in the LaCrosse area southwest Wisconsin. Studies commenced in the late 1930's and are continuing.

An early study by Hays, et al in 1949 1/ commented: "In order to study some of the effects of cover and character of land use upon runoff and soil loss, the United States Forest Service established three small watersheds under various cover and land use conditions."

1/ Hays, O.E., McCall, A.G., and Bell, F.G., 1949, Investigations in erosion control and the reclamation of eroded land at the Upper Mississippi Valley Conservation Experiment Station near LaCrosse, Wisconsin, 1933-43, USDA Tech. Bulletin 973. 87 pages.

"Two of the tracts, one timbered (watershed A) and one cleared of timber in 1932 (watershed G), are grazed. The third tract (watershed B) which is well forested with second growth hardwoods is maintained in a fully protected condition. In each case, a diversion ditch has been built around the upper margin of the watershed so that only the precipitation which actually falls within its boundaries enters into the runoff calculations. Watersheds A, B, and G have drainage areas of 2.67 acres, 11.5 acres, and 5.85 acres, respectively; the average channel gradients of A-17, B-17 and G-26 percent. The maximum gradient of A is 28, B is 50, and G is 35 percent. The common exposure is north in all cases." p. 36.

Findings (1935-1941) are tabulated as follows:

Watershed	Runoff as percent of rainfall by storm groups				Soil loss per acre by storm groups			
	Annual	High	Moderate	Low	Annual	High	Moderate	Low
	%	%	%	%	Tons	Tons	Tons	Tons
Watershed A, pastured woodland	1.16	3.37	0.15	-	0.14	0.14	-	-
Watershed B(1), protected woodland	(1)	-	-	-	-	-	-	-
Watershed G, cleared pasture	.35	.93	.45	-	.05	.05	-	-
Unterraced pasture watershed 2/	4.65	13.86	1.05	-	-	-	-	-
Stripcropped watershed 2/	7.34	20.85	2.73	0.23	2.66	2.23	0.28	0.15
Unterraced cultivated 2/3/ watershed	7.49	19.09	3.75	1.37	5.00	3.76	0.59	0.65
Cultivated terrace	10.39	27.33	5.58	1.09	1.20	0.91	0.23	0.06

1/ 0.02 inches of runoff in 1935.
2/ Period 1937-1943.
3/ Filter strip at bottom of watershed, 1937-1941.

Soil-block lysimeter experiments 1/ at LaCrosse were conducted for six years on blocks of Fayette silt loam with the following results:

1/ Sartz, R.S., 1963, Water yield and soil loss from soil-block lysimeters planted to small trees and other crops, southwestern Wisconsin. Lake States Forest Expt. Sta., St. Paul, Minn., 23 pages, illus. (U.S. Forest Service Res. Paper LS-6).

Annual Soil Loss in Tons Per Acre*

Year	Mulched Lys. No. 1	Hardwoods Lys. No. 4	Unmulched Hardwoods	Pine	Grass	Annual Grain
1936-37	0.15	0.19	17.09	0.12	1.08	11.15
1937-38	0.03	0.06	2.45	0.01	0.01	15.71
1938-39	0.03	0.10	0.39	0.02	0.03	55.80
1939-40	0.04	0.01	0.13	0.01	0.01	5.46
1940-41	0	0	0.21	0.01	0.02	12.20
AVERAGE	0.05	0.07	4.05	0.03	0.23	20.06

*From May to April 30. Soil loss was not measured after September 30, 1941.

An eight-year study of small single land use watersheds by Sartz 1/ in southwestern Wisconsin gave the following maximum amounts of suspended sediment in runoff water in parts per million. "Sediment content of the runoff water was related to stage of flow in a very gross way." p. 316.

Land Use	Parts Per Million
Clean tilled	238,000
Heavily grazed open pasture	82.000
Heavily grazed forest pasture	55,900
Lightly grazed open pasture	13,000
Alfalfa meadow	19,800
Abandoned field	300
Logged forest	3,600
Undisturbed forest	100

1/ Sartz, R.S., 1970, Effect of land use on the hydrology of small watersheds in southwestern Wisconsin, Pub. 96, Intl. Assn. of Scientific Hydrology, Wellington, N.Z.

Soil losses from forest or woodland are variable and dependent on many factors. Observation and experimentation have given us general statements that are useful in studying the problem. For example, the greater the amount of watershed in forest, the less the sediment yield. A study by Wark and Keller 1/ considered sediment sources and transport in the Potomac River Basin.

No. of Sub-basins	Percent of Forest Cover	Average Annual Sediment Yield Tons/Sq. Mi.
15	20-50	90-500
17	60-90	20-200

A regression through the scatter gave the investigators the following mean yields:

Forest Cover Percent	Sediment Yield Tons/Sq. Mi./Yr.	Sediment Yield Tons/Ac./Yr.
20	400	0.625
40	200	0.313
60	90	0.014
80	45	0.007
100	22	0.003

Conclusions from many studies were summarized by Lull and Reinhart in their review 2/ of the influence of forest on floods in the Eastern United States:

"Erosion from the undisturbed forest occurs almost entirely within the stream channel as discharge detaches soil particles and carries them downstream; the upland forest, between the channels, contributes little or no sediment to the stream.

"Erosion is not caused by cutting of trees, per se, but by the soil disturbance that usually accompanies or follows cutting.

1/ Wark, J.W., and Keller, F.J., 1963, Preliminary Study of Sediment and Transport in the Potomac River Basin, U.S. Geol. Survey and Interstate Commission on Potomac River Basin, 28 pages.

2/ Lull, Howard W., and Reinhart, Kenneth G., 1972, Forests and floods in the eastern United States, NE. Forest Exp. Sta., Upper Darby, Pa., 94 pages, USDA Forest Serv. Res. Paper NE-226.

"In hilly and mountainous areas with great erosion potential, soil losses may be reduced where stony soils 1/ quickly slow the erosion process by forming an erosion pavement." p. 84.

An inference was "where plantations are established on eroding land, erosion will eventually cease as litter and humus begin to protect the soil and as overland flow is stopped." p. 85.

"The forest is the best of all possible natural cover for minimizing overland flow, runoff, and erosion." p. 86.

For the Southeast Wisconsin Rivers Basin study, predicted soil losses from forest and woodland were related to percent tree cover. Values may be too low, particularly for economic subareas 4 and 5, but experimental data is lacking.

Subarea	Percent Forested	Predicted Soil Loss Tons/Ac./Year
1	84.32	0.007
2	39.57	0.011
3	17.55	0.014
4	9.21	0.160
5	9.56	0.160

Miscellaneous Erosion

The responses to question 7 on miscellaneous erosion from scour, mine spoil banks, inland lake shore erosion and miscellaneous erosion is summarized in Table 27 .

TABLE 27. - Miscellaneous Erosion by Type and Subarea.

Economic Subarea	Scour of flood plain soils	Eroding Mine spoil banks	Inland lake shore erosion	Other Miscellaneous
1	-	2	1	1
2	2	-	5	2
3	2	-	2	3
4	-	2	1	1
5	4	-	1	4
TOTAL	8	4	10	11

1/ or stone lines in soil profile.

Inland Lakeshore Erosion

Inland lakeshore erosion frequently occurs but has seldom been quantified. Many problems are associated with this type of erosion. Short-range effects are loss of shoreland and marsh areas where game-fish may spawn. Lake area increases while depth decreases. With shallowing there is an increase in temperature and turbidity. Fertility increase and lake eutrophication is usually accelerated.

While ten counties stated that inland lakeshore erosion was a significant problem, only Lake Winnebago (Fond du Lac, Calumet and Winnebago counties), Lake Poygan (Waushara County), and Lake Koshkonong (Jefferson County) were mentioned by name.

Lake Koshkonong (Jefferson County) is an aging lake with an eroding shoreline. Between 1916 and 1971 the water surface area has increased by shoreline erosion 858 acres. 1/ See modified sketch from Ball, p. 22.

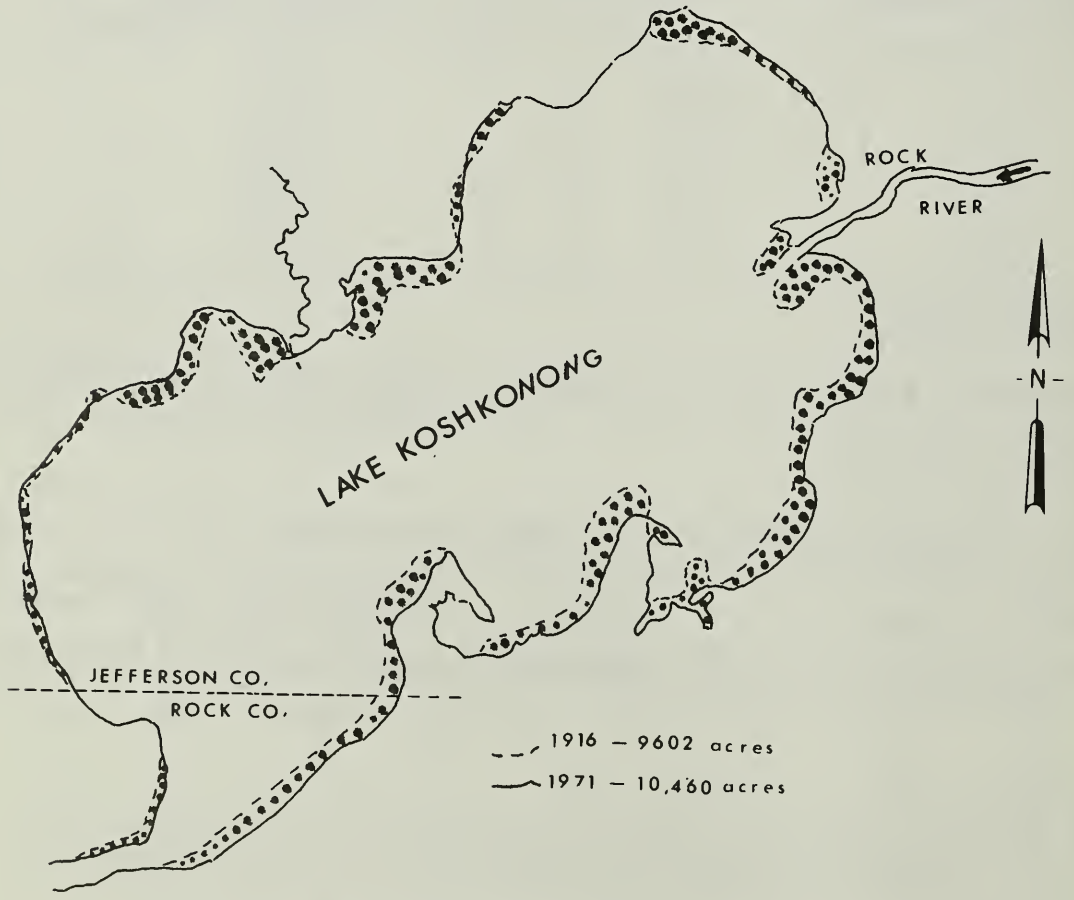


Fig. 15. - SHORELAND EROSION BETWEEN 1916 AND 1971, LAKE KOSHKONONG. JEFFERSON COUNTY, WISCONSIN.

1/ Ball, J. R., 1971, Shoreland is vulnerable, Wisconsin Conservation Bulletin, Wis. Department of Natural Resources, V. 36, No. 4, p. 22.

Shoreline Erosion - Lake Michigan

The arcuate 495 mile mainland shoreline of Lake Michigan in Wisconsin is fairly regular except for the numerous bays and indentations of the Door Peninsula which separates Green Bay from Lake Michigan.

Surfaced by soils, the Pleistocene deposits of Wisconsin age along the shore are a part of moraine systems formed by the Lake Michigan and Green Bay ice lobes. These features are associated with ground moraine, outwash, and terraces, beach and ridge remnants of the glacial "Great Lakes." With ice recession and the lowering of lake outlets, a scenic shoreline has developed. Occasionally as on the east shore of Green Bay along the Door County Peninsula, near Sheboygan, and north of Racine, there are outcrops of Ordovician or Silurian limestones.

Shoreline erosion along Lake Michigan is chiefly caused by temporary changes in lake levels, wave action, ice action, seepage, runoff of water, and the activities of man and animals. This results in loss or depreciation of property, muddy or turbid water, loss of lake capacity, damage to fish and wildlife, and higher costs for water filtration. In inland lakes eutrophication is accelerated.

Rates of erosion are dependent on several factors but as Alden, 1918, The Quaternary Geology of Southeastern Wisconsin, points out on pages 338-339:

> "The rate of encroachment of the lake upon the land depends very largely on the character of the material forming the shore. Where much sand and soft clay occur in the bluff, as in Milwaukee Bay and in the bluff near Racine, erosion is easy and the bluff recedes rapidly. In the towns of Mequon and Grafton, Ozaukee County, there has been much slumping down of the bluff in places. Where dense stony till occurs, particularly at the base of the bluff, erosion is much slower and salients are formed, as at Fox Point and North Point north of Milwaukee and south of Milwaukee Bay. Where the rock outcrops at the water's edge, as at the lighthouse point north of Sheboygan and at Wind Point north of Racine, recession of the shoreline has practically ceased and prominent points have resulted.
>
> "Since the settlement of the lake-shore region, this encroachment of the lake upon the land has been a serious menace to property, and in late years it has become necessary to build piers and breakwaters at frequent intervals to protect the shore from erosion. This artificial interference has greatly reduced the effective work of the waves."

Lake Michigan shoreline erosion is seen on Figure 17. Figure 18 shows bank sloping and riprapping for protection and stabilization.

Fig. 16. - SHORELINE EROSION, LAKE MICHIGAN
KENOSHA COUNTY, WISCONSIN - 1972

Fig. 17 - LAKE MICHIGAN SHORELINE PROTECTION
AND STABILIZATION
RACINE COUNTY, WISCONSIN

Andrews, in 1870, 1/ studied the Lake Michigan shoreline between Manitowoc, Wisconsin and Evanston, Illinois with a period of observation which varied from ten to 35 years. His results and conclusions are listed below:

Location	Feet a Year
At Evanston, Illinois the erosion is	16.95
At the Old Pier, 2 miles farther north	4.90
One mile farther north	3.08
At Winnetka	4.05
One mile farther north	6.05
Lake Forest	1.65
Waukegan	.00
Two miles farther north	.00
State line, Wisconsin-Illinois	16.50
Kenosha, Wisconsin	12.00
Two miles farther north	3.00
Three miles farther north	12.00
Racine Point	16.00
Racine	6.00
Oak Creek .	2.00
One mile farther north	1.60
Milwaukee	6.25
Port Washington	2.30
One mile farther north	1.50
Place farther north	3.00
Place 4 miles south of Sheboygan	8.00
Sheboygan	6.25
Manitowoc	5.00

1/ Andrews, Edmund, The North American lakes considered as chronometers of postglacial time: Chicago Acad. Sci. Trans., Vol. 2, Art. 1, pp. 7-8, 1870.

"Milwaukee stands very near the center of this coast line, dividing it into halves. The north half, as the above figures show, is eroded less rapidly, and the terrace of erosion is therefore narrower than in the south half. From Milwaukee to Manitowoc (about 80 miles) the erosion averages 4.33 feet a year, while between Milwaukee and Evanston it is 6.24 feet a year. The average of the two is 5.28 feet, which is therefore the average erosion of the bluffs along the whole line. This result is confirmed by numerous other observations which were of value but not precise enough to be entered in the list".

Two additional, and more refined sets of observation were cited by Chamberlin in 1877, 1/ for Racine County and Milwaukee County.

"Mr. S.G. Knight, of Racine, has carefully measured for the Geological Survey, from the nearest section corner or quarter post to the bank of Lake Michigan, along all the section lines in Racine County, the results of which, compared with the Government survey made in 1836, are given in the following table. Had these measurements been made at right angles to the shore line, the result would have been a trifle less; but as some portions of the bank have been protected artificially we may assume the result as a close approximation to the actual amount of loss during the past 38 years in Racine County. These measurements will have their value many years hence.

1/ Chamberlin, T.C., Geology of Wisconsin, Vol. 2, pp. 231, 232, 1877

Erosion of the Lake Shore in Racine County, Wisconsin

Section Lines	1836	1874	Loss
	Chains.	Chains.	Chains.
North line of sec. 6, T.4, R.23	32.70	30.30	2.40
North line of sec. 7, T.4, R.23	34.68	33.45	1.23
West line of sec. 8, T.4, R.23	30.18	29.70	0.48
North line of sec. 17, T.4, R.23	16.38	14.60	1.78
West line of sec. 16, T.4, R.23	10.86	9.75	1.11
North line of sec. 21, T.4, R.23	15.58	14.50	1.08
West line of sec. 22, T.4, R.23	19.39	18.43	0.96
North line of sec. 27, T.4, R.23	26.39	26.39	0.00
North line of sec. 34, T.4, R.23	16.04	15.47	0.57
West line of sec. 34, T.4, R.23	31.50	30.00	1.50
South line of sec. 33, T.4, R.23	28.87	27.34	1.53
North line of sec. 4, T.3, R.23	28.03	26.50	
North line of sec. 9, T.3, R.23	18.82	18.00	0.82
North line of sec. 16, T.3, R.23	27.80	20.60	6.20
North line of sec. 21, T.3, R.23	21.25	18.00	3.25
North line of sec. 28, T.3, R.23	32.22	31.16	1.06
West line of sec. 28, T.3, R.23	30.20	23.87	6.33
North line of sec. 32, T.3, R.23	34.85	32.40	2.45
South line of sec. 32, T.3, R.23	46.60	44.73	1.87

Mean of 18 places, in chains	1.92
The same, in feet	126.72
Loss per annum in feet	3.33

The following measurements were made to ascertain the amount of the abrasion of the west shore of Lake Michigan in Milwaukee County since the Government survey made in 1835 and 1836:

Section Lines	1836	1874	Annual Loss
	Chains	Chains	Feet
South line of sec. 1, T.5, R.22	45.61	44.50	1.90
South line of sec. 36, T.6, R.22	15.90	14.40	2.60
South line of sec. 24, T.6, R.22	19.29	18.70	1.00
South line of sec. 21, T.7, R.11	8.72	8.42	0.50
South line of sec. 15, T.7, R.22	5.37	2.82	4.31
South line of sec. 10, T.7, R.22	43.35	41.64	2.90
South line of sec. 3, T.7, R.22	19.34	17.36	3.33
South line of sec. 37, T.8, R.22	22.00	18.69	5.61
Mean annual loss			2.77

Rates by Andrews are considerably higher than those given by Chamberlin for Racine and Milwaukee.

Ball and Powers 1/ reported that shoreline recession was measured using marker trees in Township 2N, Range 23E, north of Kenosha, Kenosha County, Wisconsin. Measurements commenced in 1918 and ended in 1929.

TABLE 28. - Shoreline Recession - Kenosha County, Wisconsin 1918-1929

Time Period	Marker Tree	Location	Total Recession	Annual Recession
	1	S. line Sec. 19	29 ft.	9.67 ft.
	2	3 rods N. Tree 1	33 ft.	11.00 ft.
1918-1921	3	N. line SE 1/4, SE 1/4, Sec. 19	41 ft.	13.67 ft.
	4	S. line SE 1/4, SE 1/4, Sec. 19	45 ft.	15.00 ft.
	1	Marker Tree Lost by Recession		
	2	3 rods N. Tree 1		0.4 ft.
1921-1929	3	Marker Tree Lost by Recession		
	4	S. line SE 1/4, SE 1/4, Sec. 18	8.5 ft.	1.06 ft.

From 1918 to 1921 the average shoreline erosion was 37 feet with an average annual recession of 12.33 feet.

From 1921 to 1929 average shoreline recession was 5. 85 feet with an average annual recession of 0.73 feet.

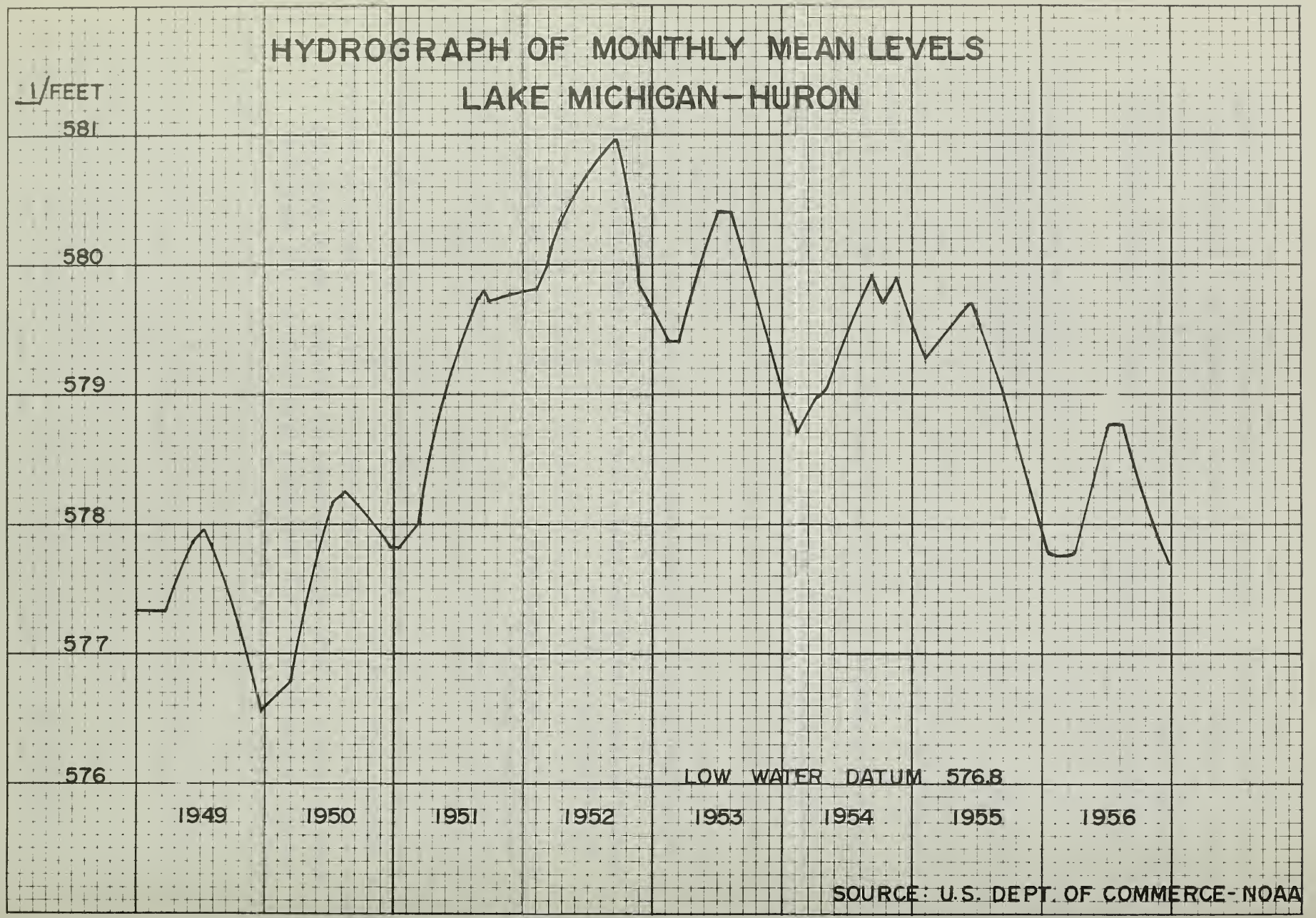
1/ Ball, J.R., and Powers, W.E., 1930, Shore Recession in Southeastern Wisconsin: Ill. Acad. Sci. Trans., Vol. 22, p. 439

In 1951 and 1952 the water level of Lake Michigan was higher than normal lake level and much shoreline property was damaged by ice, wave work and flooding. Plate III shows the high level of water in 1951 and 1952 as compared with earlier and later reports. Erosion during this time was severe and erosion rates as reported by the Corps of Engineers were as follows:

Location	Average and Variable Lake Michigan Shoreline Erosion - 1951-1952
North of Sturgeon Bay Canal for about eight miles to White Fish Point	20 feet
Between Sturgeon Bay Canal and Kewaunee	15 feet
Between Kewaunee and Manitowoc	15 feet
Between Manitowoc and Sheboygan	15 feet
South of City of Sheboygan to Sheboygan-Ozaukee County line	30 to 60 feet
North Ozaukee County line and Port Washington Harbor	10 feet
Between Port Washington and Milwaukee Harbors	5 to 20 feet
Between Milwaukee and Racine Harbors	15 feet
Between Racine Harbor and the Wisconsin-Illinois state line	Up to 75 feet

Spring storms in 1973 were particularly severe. Much property damage occurred and bluff recession was severe. No statistics are available for current damages.

PLATE III



1/ ELEVATIONS IN FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC

TABLE 29. - Shoreline Property Damage by Erosion During Extreme High Water Stage - Lake Michigan 1951-1952 1/

Location	Actual 1951-1952 Value	Updated 1970 Value
Menominee County, Michigan	$ 59,400	$ 115,600
Between Menominee Harbor and east city limits of Green Bay, Wis.	168,000	337,200
East city limits of Green Bay to northern end of Door County, Wis.	196,000	361,300
Lake Michigan shoreline of Door, Kewaunee, Manitowoc, and Sheboygan County, Wisconsin	847,500	1,607,700
Lake Michigan, Ozaukee, Milwaukee, Racine, and Kenosha Counties, Wis.	2,734,500	5,486,800

Based on the 1971 Corps of Engineers report, there are currently four areas of Lake Michigan shoreline with critical erosion problems in the Southeast Wisconsin Rivers Basin.

County	State	Critical Erosion Reach Length in Miles
Kenosha	Wisconsin	5.0
Racine	Wisconsin	4.0
Milwaukee	Wisconsin	2.0
Milwaukee	Wisconsin	7.0
Ozaukee	Wisconsin	8.0
TOTAL		26.0

SOURCE: 1/ Table 4, U.S. Army Corps Engineers, North Central Division, 1971, Great Lakes Division Inventory Report, National Shoreline Study.

Eroded material from the bluffs is sorted and redistributed on shore, near shore, or off shore, with the finer silts and clays deposited in the deeper waters. Lag gravels and boulders are concentrated at the base of cliffs and sand accumulate as beach deposits, spits, bars and other constructional features. Much sand is transported southward by a long shore current. This continuous transport blocks many streams and may interfere with harbor navigation.

Specific maintenance dredging costs for 14 operations at Kewaunee Harbor, Wisconsin, Economic Subarea 3, were obtained 1/ from the Department of the Army, Chicago District Corps of Engineers. Dredging was done in 14 of the 20 years and "disposal of material was in deep water in the lake." Fiscal year, quantity, and cost were as follows:

TABLE 30. - Kewaunee Harbor Maintenance Dredging and Cost

Fiscal Year	Quantity (Cubic Yards)	Cost
1951	27,540	$12,456
1955	666,130	28,014
1957	47,165	29,207
1960	58,230	39,282
1961	33,747	23,582
1962	39,682	22,535
1963	61,104	42,612
1964	80,594	61,009
1965	26,605	31,606
1966	122,921	85,478
1967	12,325	20,606
1968	101,300	73,444
1969	24,625	27,288
1970	54,750	64,321
TOTALS	756,718	$561,440

Using a wet weight of 79 pounds per cubic foot, this would average 40,352 tons per annum, 1951-1970.

1/ Ltr: Chicago District Corps of Engineers, Sept. 28, 1971, to G. J. Barber, State of Wisconsin Soil Conservation Board.

Harbor dredging at Octono, Wisconsin by the Corps of Engineers is currently on a periodic basis. The depth to be maintained for recreational craft at this harbor is eight feet. The original dredging authorization for a commercial harbor was to a depth of 15 feet in an area approximately 3,000 feet long and a width of about 100 feet. Listed below are cubic yards of sediment dredged from 1933 to 1963. The yardage also includes dredging into Green Bay beyond the breakwaters. It is not known if early dredging was to a depth of 15 feet.

1933 - dredged 56,000 cubic yards
1936 - dredged 43,000 cubic yards
1940 - dredged 44,000 cubic yards
1948 - dredged 16,600 cubic yards
1963 - dredged 35,000 cubic yards

Fig. 18. - SEDIMENT DREDGED FROM FOX RIVER NEAR GREEN BAY, BROWN COUNTY, WISCONSIN

Less detailed, but significant figures were abstracted from Table 18-44, Appendix 18, Erosion and Sedimentation, Great Lakes Basin Framework Study.

TABLE 31. - Maintenance Dredging in Lake Michigan Harbors

Harbor or Other Navigation Facility	Maintenance Dredging-Lake Michigan	
	Average Annual Cubic Yards	Periodic Cubic Yards and Year
Menominee, Michigan	-	7,000 (1948)
Oconto, Wisconsin	-	16,000 (1948)
Sturgeon Bay, Wisconsin	-	30,000 (1948)
Green Bay, Wisconsin	137,000	-
Two Rivers, Wisconsin	51,000	-
Manitowoc, Wisconsin	43,000	-
Sheboygan, Wisconsin	23,000	-
Milwaukee, Wisconsin	70,000	-
Racine, Wisconsin	30,000	-
Kenosha, Wisconsin	29,000	-

Future dredging disposal costs will be considerably more expensive since materials may not be barged and dumped off shore.

Sediment Deposition

Sediment deposits on flood plains, in channels, reservoirs, man-made ponds, or natural lakes, recreational sites, and urban areas result from over bank flooding. Common types of physical damage are:

1. Burial of fertile soils by less fertile sediment.

2. Damage to growing crops and burial of crops.

3. Impairment of drainage with accompanying raise of the water table and an increase in swampy areas of alluvial land.

4. Filling of channels causing more frequent flooding and increased flood heights. Channel filling may result in changes of the channel course.

5. Filling of reservoirs, ponds, lakes and debris basins. See Fig. 19.

6. Damage to railroads, bridges, roads, power lines and hydro-electric facilities. Ditches and road grades may be filled to a degree where regrading and clean out is necessary.

Fig. 19. - SILTED IN RESERVOIR
WAUPACA COUNTY, WISCONSIN

Fig. 20. - SEDIMENT DAMAGE TO WILDLIFE HABITAT
WAUPACA COUNTY, WISCONSIN

7. Mortality and reduced growth of forest vegetation.

8. Urban areas, particularly with homes and commercial and industrial buildings, damaged by sedimentation and increased flood heights.

9. Damage to recreational facilities, such as ball parks, race tracks and county fairgrounds.

10. Damage or destruction of fish and wildlife habitat. See Fig. 20.

11. Increased treatment cost of municipal and industrial water supplies.

Infertile Overwash

County responses were made as to the severity of infertile overwash (Table 32), the estimate of acres of infertile overwash deposited per year (Table 33), and the length of time to recover soil fertility after overwash deposition (Table 34).

TABLE 32. - Deposition of Infertile Soil Material on County Flood Plains by Economic Subarea.

Economic Subarea	Problem Negligible To Slight	Moderate Problem	Severe Problem
1	4	2	0
2	9	2	0
3	4	2	0
4	6	1	0
5	7	2	0
TOTAL	30	9	0

TABLE 33. - Estimate in Acres Per Year-Deposition of Infertile Soil Material on County Flood PLains by Economic Subarea.

Economic Subarea	Deposition of Infertile Soil Material			
	10 Ac/Yr	10-100 Ac/Yr	100-500 Ac/Yr	More than 500 Ac/Yr
1	4	2	0	0
2	5	4	2	0
3	3	2	1	0
4	2	5	0	0
5	4	5	0	0
TOTAL	18	18	3	0

TABLE 34. - Length of Time to Recover Soil Fertility From Infertile Overwash

Economic Subarea	Soil Fertility Recoverable In			
	Short Time	Several Years	A Long Time	Never
1	4	1	-	1
2	7	2	1	-
3	2	2	1	-
4	5	2	-	-
5	6	3	-	-
TOTAL	24	10	2	1

1/ Brown County, Economic Subarea 3, and Winnebago County, Economic Subarea 2 made no response.

Sedimentation in Drainage Channels

Sediment accumulation in drainage channels was categorized as a slight, moderate, or severe problem. Table 35 presents the degree of problem.

TABLE 35. - Degree of Problem-Sediment Accumulation in County Drainage Channels.

Economic Subarea	Sediment Accumulation in County Drainage Channels		
	Slight Problem	Moderate Problem	Severe Problem
Subarea 1	3	3	0
Subarea 2	3	4	4
Subarea 3	0	4	2
Subarea 4	4	1	2
Subarea 5	4	3	2
TOTAL	14	15	10

Table 36 is a summary of annual channel clean-out.

TABLE 36. - Annual Channel Clean-out by Economic Subarea

Economic Subarea	Yearly Channel Clean-out of Sediment		
	Less Than 10 Miles of Channel	10 to 50 Miles Channel Clean-out	More Than 50 Miles Channel Clean-out
1	6	0	0
2	8	1	Oconto County
3	4	2	0
4	6	1	0
5	6	3	0
TOTAL	30	7	1

Counties estimated their annual cubic yards of sediment removed from channel as percent less than 5,000 cubic yards per mile, percent between 5,000 to 15,000 cubic yards per mile, percent more than 15,000 cubic yards of cleanout. All but six counties had less than 15,000 cubic yards of cleanout per year. In subarea 2 Oconto County had 10 percent, and Outagamie 20 percent of the cleanout greater than 15,000 cubic yards. In subarea 3, Sheboygan County had 75 percent of the cleanout more than 15,000 cubic yards. Waukesha County, subarea 4 had 10 percent of the annual cleanout at more than 15,000 cubic yards. There were two counties in Subarea 5 - Dodge with 10 percent, and Jefferson with 25 percent of channel cleanout greater than 15,000 cubic yards.

Miscellaneous Forms of Erosion and Sedimentation

There are many miscellaneous forms of erosion and sedimentation that have been occasionally observed but seldom quantified.

1. Fly ash is deposited from industrial complexes.

2. Banks and roadsides are eroded by burrowing animals. This type of erosion is most conspicuous during the early spring when vegetation is sparse.

3. There is erosion and sedimentation from internal farm roads, tracks and cattle underpasses.

Fig. 21. - ERODED PASTURE NEAR
CATTLE UNDERPASS
DODGE COUNTY, WISCONSIN

4. Much sand is used during winter months on roadways. The sand is very quickly transported elsewhere and deposited by the roadside or in drainage ditches.

5. Numerous beaches in urban parks have an annual replenishment of sand for the beach area. Inevitably the sand apron is eroded to some degree and deposited in the lake.

6. Near shore lake bottom sediments are eroded and pushed by winter ice into ramparts or terraces. During the spring this material may be redistributed or removed.

7. Pasture erosion by hogs or other domestic animals - Fig. 22

8. Heavy use areas in city parks are often severely eroded, particularly at ponds where ducks or swans are fed. University of Wisconsin Arboretum Director Roger Anderson estimated 15 feet of shore recession in the past 30 years at the arboretum duck pond. This particular pond is adjacent to a heavily traveled road in the city of Madison and has numerous visitors. The year round population of 300 to 400 ducks is excessive.

Fig. 22. - HOG PASTURE EROSION
IOWA COUNTY, WISCONSIN

9. Improper design of concrete floodways, culvert approaches, aprons or dams may result in structural failure during storm episodes. Rather conspicuous erosion and sedimentation may result. See Fig. 23, page 61.

10. Wind blown materials are deposited in drainage ditches, along fence lines, and on roads.

Fig. 23. - ERODED AND COLLAPSED CULVERT APRON
MADISON, DANE COUNTY, WISCONSIN

Gross Erosion and Sedimentation

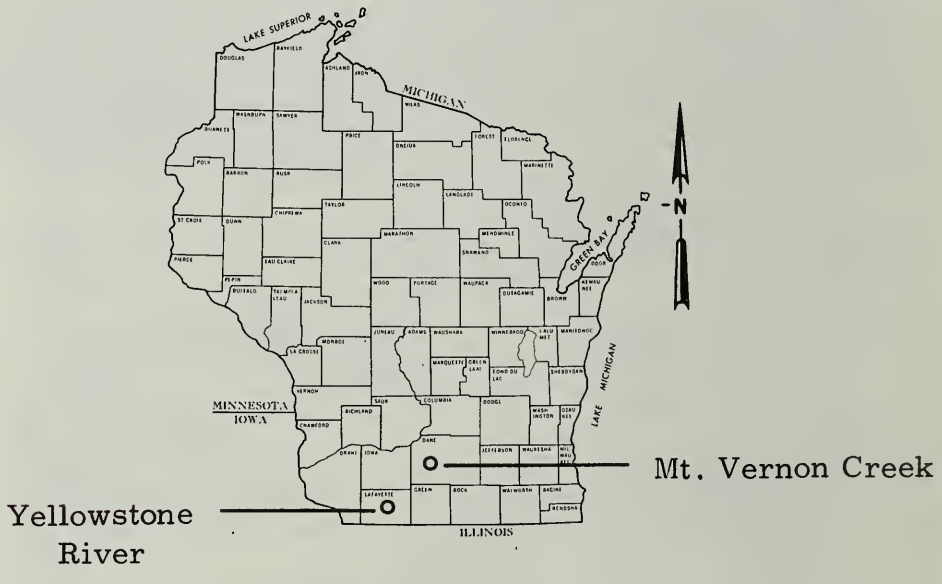
Gross erosion and sedimentation are dynamic processes with highly variable rates. Topography, geology, soils, climate, vegetation and man are the major determinants. The quantitative aspects are highly significant to agriculture, industry and the individual.

Quantitative gross erosion and sedimentation rates are obtained through field studies, experimental watershed observations, reservoir sedimentation studies, suspended sediment load measurements and bed load measurements.

The United States Geological Survey has made numerous suspended load studies in the State of Wisconsin. Their first report in 1963 1/ included two streams in the Rock River Basin, subarea 5. Samples were taken monthly from 1954 through September 1960.

1/ Collier, Charles R., 1963, Sediment characteristics of small streams in southern Wisconsin; 1954-1959, U.S. Geol. Survey, Water Supply Paper 1669-B, iv, B 31-34.

Stream	County	Annual Sediment Yield in Tons per Square Mile		
		Average	Minimum	Maximum
Mount Vernon Creek	Dane	96	48	171
Yellowstone River	Lafayette	236	34	730



1970 Hindall and Flint 1/ reported on sediment yields of additional isconsin streams. Length of record was variable. Data included 17 asin watersheds.

onomic Subarea	U.S.G.S. Station Number	Location in Wisconsin	Drainage Area Sq. Miles	Average Discharge CFS	Tons/Sq. Mi. Short* Term	Long** Term
1	4-610	Brule River near Florence	389	343	12.0	13.0
1	4-637	Popple River near Fence	131	115	6.1	6.6
1	4-660	Menominee River near Pembino	3,240	2,888	47.0	48.0
2	4-735	Fox River at Berlin	1,430	1,084	39.0	43.0
2	4-800	Little Wolf River at Royalton	514	394	5.0	4.8
2	4-810	Waupaca River near Waupaca	271	237	34.0	34.0
3	4-860	Sheboygan River at Sheboygan	432	232	79.0	68.0
4	4-870	Milwaukee River at Milwaukee	686	381	16.0	14.0
4	4-872.4	Root River at Racine	187	75	67.0	47.0
5	5-4240	East Branch Rock River near Mayville	179	85	13.0	14.0
5	5-4260	Crawfish River at Milford	732	329	37.0	44.0
5	5-4325	Pecatonica River at Darlington	274	183	302.0	323.0
5	5-4330	East Branch Pecatonica River near Blanchardville	221	139	207.0	250.0
5	5-4335	Yellowstone River near Blanchardville	29	16	335.0	373.0
5	5-4360	Mt. Vernon Creek near Mt. Vernon	16	17	92.0	100.0
5	5-4365	Sugar River near Brodhead	527	336	50.0	60.0
5	5-4305	Rock River at Afton	3,300	1,703	26.0	30.0

* Short term, period of suspended sediment record.
** Long term, extrapolated to a 23-year base period, 1945-1967.

Hindall, S.M., and Flint, R.F., 1970, Sediment yields of Wisconsin streams, U.S. Geol. Survey, Hydrologic Investigations, Atlas HA-376.

The Soil Conservation Service has made no suspended or bed load studies in the Basin, but is planning reservoir sedimentation studies.

Two type I river basin studies have considered gross erosion and sediment yield in parts of the Southeast Wisconsin River Basin.

The Upper Mississippi River Basin study, completed in 1972, has in Volume III Appendix G; Fluvial Sediment, figure G-31, the annual sediment yield for 100 square mile drainage area in tons per square mile. See Figure 24 for a reproduction of the Wisconsin-Northern Illinois area.

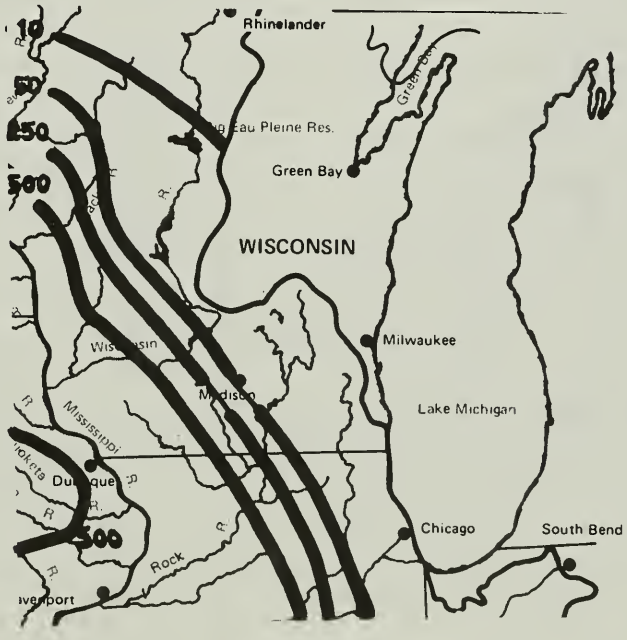


Fig. 24. - ANNUAL SEDIMENT YIELD IN TONS PER SQUARE MILES FOR 100 SQUARE MILE DRAINAGE AREA

SOURCE: Upper Mississippi River Basin, Vol. III, G-30.

The Great Lakes Basin Framework Study, Appendix 18, has a number of sediment yield maps for various sizes of drainage area, and a county list of "current weighted average annual sheet erosion rate." 1/ These figures are based on the universal soil loss equation with the "program sequence adjusted for the soil and cover characteristics of the individual county."

	Current Sheet Erosion	
	Tons/Ac./Yr.	Tons/Sq.Mi/Yr.
Economic Subarea 1		
Iron, Michigan	0.2	128
Dickinson, Michigan	0.4	256
Menominee, Michigan	0.8	512
Forest	0.2	128
Florence	0.8	512
Marinette	0.3	192
Economic Subarea 2		
Langlade	1.0	640
Oconto	1.4	896
Menominee	Not Computed	-
Shawano	2.4	1,536
Waupaca	1.9	1,216
Outagamie	3.0	1,920
Waushara	2.0	1,280
Winnebago	2.8	1.792
Marquette	1.7	1.088
Green Lake 1/	2.7	1,728
Fond du Lac 1/	3.6	2,304
Economic Subarea 3		
Door	0.8	512
Brown	2.5	1,600
Kewaunee	2.9	1,856
Calumet	2.7	1,728
Manitowoc	2.5	1,600
Sheboygan	2.9	1,856
Economic Subarea 4		
Washington	3.9	2,496
Ozaukee	5.1	3,264
Waukesha	3.7	2,368
Milwaukee	2.4	1,536
Walworth	4.8	3,072
Racine	4.4	2,816
Kenosha	4.3	2,752
Economic Subarea 5 2/		
Dodge	4.2	2,688

1/ Great Lakes Basin Framework Study, App. 18, pp. 18-85, 18-90, 18-91

2/ No other Wisconsin or Illinois counties in Great Lakes Basin Framework Study

Predicted gross erosion rates have been made by the Soil Conservation Service since 1956 for the small watersheds program PL-566. The Musgrave equation modified for cornbelt states was used to determine present and future rates of sedimentation behind floodwater retarding structures.

Some 79,453 cropland acres were inventoried for computing soil losses, and 72,720 acres were studied for future cropland soil losses. Rotation, practice, soil type, percent and length of slope, land capability class and subclass, and management were obtained for all farm units above 55 structure sites. At least 50 percent of the land was under cooperative agreement with a county soil and water conservation district.

Using data from 55 structure sites in 19 watersheds, the average predicted cropland soil loss is 5.14 tons per acre per year. Based on changes in land use and additional land treatment measures, future cropland soil losses were predicted to be 4.01 tons per acre per year. See Figure 25.

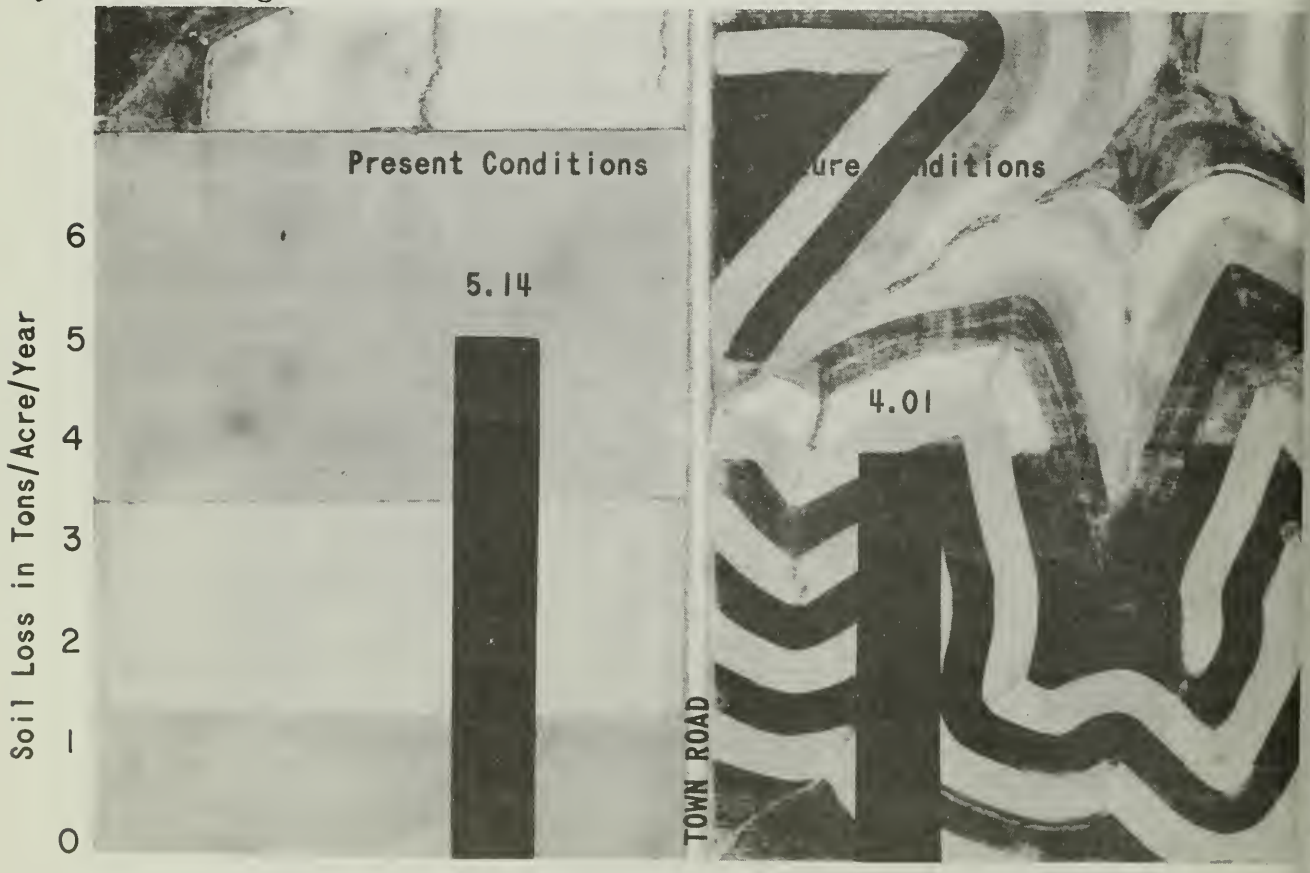


Fig. 25. - AVERAGE CROPLAND SOIL LOSS IN TONS PER ACRE PER YEAR, PRESENT CONDITIONS AND FUTURE CONDITIONS WITH LAND TREATMENT PROGRAMS - SOUTHWEST, WISCONSIN

Since the majority of sites were in southwest Wisconsin (Driftless Area of the Western Upland), soil losses are considerably higher than in the more wooded northern half of the Basin.

For the Basin report, 14 to 20 soil and water conservation district cooperator farms per county were studied in detail. The farm units, selected by each county district conservationist, were representative of Conservation Needs Inventory Watersheds as delineated in RR No. 10, Areal Measurement and Nomenclature of Watersheds in the Southeast Wisconsin River Basin. Information on each farm unit was placed on a form. See Plate IV. Sampled data by economic subarea is summarized below:

Economic Subarea	No. of Farm Units Studied	Total Acreage
1	96	19,267
2	174	31,729
3	96	14,333
4	123	16,108
5	146	30,463
BASIN TOTAL	635	111,900

Using a modified Musgrave equation $E=KCR\frac{(\%S)}{(10)}1.35\frac{(LS)}{(72.6)}^{.35}ACPM$

Where:
E is erosion in tons per acre
K is a function of soil type
R is rainfall erosiveness
S is slope
LS is length of slope
A is area in acres
C is rotation - crops
P is practice - as contour farming
M is management factor

predicted soil losses were computed 1/ for the sample by Mr. Peter Hanson expanded to conform to Conservation Needs Inventory land use statistics by county. Streambank, roadside, urban and built-up erosion were integrated for sediment yield map by CNI watershed. See Plate V. It should be emphasized that these figures are guide figures and should only be used as a first approximation in a small watershed. Detailed inventory must be made to assure correct land use proportions, soil types, capability classes of land, rotations, practices and management.

1/ The olivetti-underwood Programma 101 was used.

Rev.
WI-168
9/69

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PLATE IV

(4)
CHECK

UPLAND SHEET EROSION - WISCONSIN
FARM UNIT DATA

COOPERATOR ☑
NON-COOPERATOR ☐

NAME O F.

T. 18 N
SITE R. 15 E WATERSHED (2) Wolf-Fox
Sec. 4, 9, & 10 COUNTY Winnebago STATE Wisconsin

LAND USE	ACRES
CROPLAND	170
PASTURE-GOOD	6
PASTURE-POOR	-0-
WOODLAND-GOOD	-0-
WOODLAND-POOR Wildlife	4
ROADS AND BUILDINGS	7
OTHER	-0-
TOTAL ACREAGE	187

MANAGEMENT	CHECK HERE
SPRING PLOW	
FALL PLOW	✓
RESIDUES LEFT	
TOBACCO-WITH COVER CROP	
TOBACCO-NO. COVER CROP	
PLOW PLANT	
WHEEL TRACK PLANTING	

CROPLAND - PRESENT LAND USE

	CAPABILITY CLASS	ACRES	ROTATION	*PRACTICE
93 -	Brillion Silt Loam (IIe)	4 acres	-	Continuous hay
151 -	Oshkosh Silty Clay (IIe)	12 acres	-	crop rotation (C-C-C-S-H-H-H)
171 -	Poygan Silty Clay (IIw)	55 acres	-	crop rotation (C-C-C-S-H-H-H)
254 -	Tustin Sandy Loam (IIe)	57 acres	-	crop rotation (C-C-C-S-H-H-H)
341 -	Kewaunee Silt Loam (IIe)	43 acres	-	crop rotation (C-C-C-S-H-H-H)

Note: All acreage subject to surface drainage and tile with outlet into pump storage. 70 acres remain to be tiled out.

*CONTOUR STRIPCROPPING OR TERRACING; CONTOURING; CROSS SLOPE; NONE (UP AND DOWN HILL)

FOR PLANNED LAND USE ATTACH A SECOND SHEET OR INDICATE PRESENT AND PLANNED LAND USE ARE THE SAME.

Average percent & length of slopes for Winnebago Co:

e	s	w
2-5%	1-5%	0-1%
250'	175'	300'

-70-

Predicted gross erosion by county is given in Table 35 for Subarea 5. The results are considerably less than would be expected if sampling had been expanded to include an equal number of farms owned by noncooperators. The district (county soil and water conservation district) cooperator follows a conservation resource plan prepared with a district conservationist of the Soil Conservation Service. The plan recommends management practices that will minimize soil erosion on the county soils and slopes.

TABLE 37. - Predicted Gross Erosion Economic Subarea 5.

County	Predicted Gross Erosion	
	Tons/Ac./Yr.	Tons/Sq.Mi./Yr.
Dane	2.18	1,395
Dodge	1.82	1.165
Green	5.43	3,475
Iowa	1.49	954
Jefferson	0.75	480
Lafayette	1.91	1,222
Rock	4.53	2,899
Stephenson Co., Illinois	1.58	1,011
Winnebago Co., Illinois	3.56	2,278

Estimated gross erosion in thousands of tons for the Basin and by economic subareas is given in Table 38, page 73. In all economic subareas except No. 4, cropland soil losses far exceed soil lost from other land uses. In economic subarea 4 more soil is being eroded from urbanizing land than from cropland. Predicted soil loss from cropland ranges from 0.65 tons per acre per year in subarea 1 to 3.45 tons per acre per year in subarea 5. A weighted average for Basin cropland loss would be 2.02 tons per acre per year.

TABLE 38. - Estimated Soil Loss by Subareas
Southeast Wisconsin Rivers Basin

Land Use	Subarea 1	2	3	4	5	Basin Total
			1000 Tons			
Cropland	191	2,778	1,110	1,839	9,100	15,018
Pasture	4	25	10	9	120	168
Forest	22	20	4	25	48	119
Urban-Built Up	94	405	301	2,448	1,324	4,572
Other	43	59	19	22	68	211
Totals	354	3,287	1,444	4,343	10,660	20,088

Land Treatment for Erosion and Sediment Control

A primary consideration for maximum resource development in the Basin is land treatment. The plan includes a proposal for accelerating the application rate of land treatment. It is estimated that under ongoing programs, about 40 percent of the total crop and pasture treatment needs will be met by the year 2000. An accelerated land treatment goal by the year 2000 would be the application of 67 percent of the needed practices. This can be implemented under existing USDA programs.

Of the 6.8 million acres of cropland in the Basin, about 43 percent or 3 million acres are considered as adequately treated. The remaining 3.8 million acres are in need of some type of treatment. With the going rate of application, it is estimated that only about 1.5 million acres of cropland will be treated by the year 2000. Under the proposed land treatment goals, an additional one million acres of cropland will need to be treated.

There are somewhat less than one million acres of pasture or six percent of the Basin area. Of this total, about 11,000 acres are not feasible to treat and 38,000 acres require a change in land use. About 268,000 acres, or 29 percent, of the pasture land is considered to be adequately treated. The remaining 611,000 acres require some type

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

MICHIGAN

WISCONSIN

ILLINOIS

LAKE MICHIGAN

GREEN BAY

LEGEND

- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- STATE OR NATIONAL BOUNDARY
- COUNTY BOUNDARY
- PERENNIAL STREAM
- LAKE OR RESERVOIR
- CONSERVATION NEEDS INVENTORY BOUNDARY AND NUMBER (21a 1)

SUBBASINS

1. MENOMINEE RIVER
2. PESHTIGO RIVER
3. OCONTO RIVER
4. WOLF-FOX
5. MILWAUKEE RIVER
6. FOX RIVER (ILLINOIS)
7. ROCK RIVER
8. MINOR DRAINAGE AREAS LESS THAN 800 SQ MI

SEDIMENT YIELD

ACRE FEET PER SQ.MI. PER YEAR

- < 0.10
- 0.10 TO 0.25
- 0.26 TO 0.50
- 0.51 TO 0.75
- 0.76 TO 1.00
- 1.01 TO 1.25
- 1.26 TO 1.50
- > 1.50

SCALE 1:1,250,000

0 5 10 15 20 MILES

SOUTHEAST WISCONSIN RIVERS BASIN

ILLINOIS, MICHIGAN, WISCONSIN

SEDIMENT YIELD MAP

U.S. DEPARTMENT OF AGRICULTURE

Economic Research Service, Forest Service, and Soil Conservation Service

S, R-26, 353, 24

USDA-SCS-LINCOLN, NEBR. 1973

of treatment. Approximately 245,000 acres of pasture land will be treated through going programs by the year 2000. To meet proposed goals, an additional 164,000 acres of pasture must be treated.

There are 5.1 million acres of forest land in private, county and state ownership. Of this amount, 2.9 million acres are adequately treated or have acceptable levels of management. The remaining 2.2 million acres need treatment.

Approximately 700,000 acres in the Basin are national forest lands. About 567,000 acres are presently under acceptable levels of management. The remaining 133,000 acres will come into multiple use management through an accelerated program by the year 2000.

Fig. 26. - CONTOUR STRIPCROPPING WITH
DIVERSION TERRACING
DODGE COUNTY, WISCONSIN

The estimated costs of applying the more important conservation practices in Wisconsin are given in Table 39. Unit cost is based on averaging costs from several current PL 566 watersheds. Costs could vary considerably from county to county.

TABLE 39. - Estimated Cost of Conservation Practices - Wisconsin.

Practice	Unit	Unit Cost - 1972
Conservation Cropping System	Acre	$ 2.00
Contour Farming	Acre	1.20
Critical Area Planting	Acre	300.00
Crop Residue Use	Acre	2.20
Diversions	Feet	0.25
Farm Ponds	No.	2,500.00
Farmstead Windbreak	Acre	100.00
Floodwater Retarding Str.	No.	3,000.00
Grade Stabilization Str.	No.	1,200.00
Grassed Waterway & Outlet	Acre	300.00
Minimum Tillage	Acre	1.00
Pasture & Hayland Mgt.	Acre	1.50
Spring Development	No.	220.00
Streambank Stabilization	Feet	10.00
Contour Stripcropping	Acre	4.20
Drainage Field Ditch	Feet	0.18
Gradient Terrace	Feet	0.12
Tile Drain	Feet	0.52
Tree Planting	Acre	66.00
Wildlife Wetland Dev.	Acre	120.00
Wildlife Upland Habitat Dev.	Acre	60.00

Implementation of the proposed land treatment and management program can be done through existing USDA programs by increasing funds for technical and financial assistance.

The total estimated cost of applying the 2,900,000 acres of treatment on crop and pasture land is $151,000,000 by the year 2000. The cost of the going program will be $90,000,000. The accelerated program will cost approximtely $61,000,000.

Total cost for the application of treatment measures on state, county and private forest lands by the year 2000 is estimated at $73,100,000. Cost of the going program will be $27,400,000. About $45,700,000 will be required to finance the recommended accelerated program.

Control of sediment must be preceded by controlling eroding areas of agricultural, industrial, urban development, and other land. Control of sediment at the source will minimize the time bare soils are exposed and vulnerable to erosion. Figures 27 and 28 illustrate erosion control measures.

If sediment is being transported as bedload or suspended load, dams, debris basins, or other mechanical or agricultural means are needed to help trap the sediment.

Sediment control on agricultural lands is accomplished by land treatment and structural measures and can quantitatively be determined from reportable progress items used by the Soil Conservation Service. Some 164 items are reportable.

To control sediment from streambank or channel erosion may be simple or complex, depending on climate conditions, bank height, channel width, soil materials in bank profile, and presence or absence of bedrock in the channel. The majority of eroded material is derived from unstable banks, cut-banks, bank freeze and thaw, and bank-full waters Fencing, riprap, deflectors, and bank sloping and seeding are most generally used. Occasionally debris basins or drop structures are needed in conjunction with other measures for streambank protection.

Control of roadbank erosion is most expeditiously accomplished by sloping banks to eliminate any drop offs, fertilizing, seeding, and mulching. Specialized equipment, such as a hydroseeder, will spray a mixture of fertilizer, mulch, and seed on a critical area in a very short time. Small, temporary debris basins built below construction areas will impound sediment from runoff prior to seed catch.

Remedial measures to control sediment produced by sheet and rill erosion from homesites, apartments, office buildings, or other construction are:

Debris Basins - Basins at strategic low points on a building site trap erosional debris during construction. Sediment may be redistributed and the basin obliterated when the work is done, or the basins may be made a part of the permanent water control system.

Jute Netting - Fibrous mulches, such as jute nettting, give temporary protection to bare construction sites and slopes. On other critical areas, short lived grasses can be seeded following rough grading.

Straw Mulch - Small grain, straw or hay can also be used as a mulch on exposed sites. Mulch may be anchored by boards set as baffles across the slope to spread runoff water and give further protection. Temporary stabilization can be accomplished by spraying on straw mulch with asphalt.

Fig. 27. - POND CONSTRUCTED FROM A GULLY PROVIDES FISHING, HABITAT AND WILDLIFE AND PROTECTION, OUTAGAMIE, WISCONSIN.

Fig. 28. - CONCRETE CHANNEL LEADING TO DESILTING BASIN PREVENTS EROSION BY CHANNELING RUNOFF FROM 100 ACRE WATERSHED DURING HIGHWAY CONSTRUCTION ARBORETUM - DANE COUNTY, WISCONSIN

Future projections in the year 2000 show acreage declines in agricultural lands, and an increase in acreage of water, urban and other land. The intensification of farming on a smaller acreage, coupled with increasing urbanization, demands much more in land treatment and structural measures for erosion and sediment control. Both state and federal acts will assure the control, measurement, and enforcement of pollution (in this case sediment) sources. The Federal Water Pollution Control Act of 1971, and amendments, identifies the U.S. Department of Agriculture as one of the agencies responsible for developing guidelines to identify and evaluate the nature and extent of nonpoint sources of water pollutants and the Department of Agriculture will create processes, procedures and methods to control water pollution resulting from agricultural and silvicultural activities.

Conclusions

A general summary of a 39-county study in the five economic subareas of the Southeast Wisconsin Rivers Basin indicated that unusual sheet erosion problems exist in 17 counties, wind erosion is severe in three counties, and roadbank erosion is severe in four counties. Nearly 1400 miles of roadside have an erosion problem.

Channel erosion (in gullies, waterways, and vehicle or livestock tracks) occurs often to very frequently in eight counties.

Streambank erosion along the larger streams occurs very frequently in 13 counties with more than 350 bank miles of stream severely eroded. Thirteen district conservationists indicated that their county had a significant urban erosion problem. Three counties reported a large to very large amount of urban erosion. Ten counties had significant inland lake-shore erosion. Four counties reported erosion from mine-spoil banks. Seven counties had scour on bottomlands from flood flows.

The deposition of infertile overwash on flood plain land was moderate in nine counties. No county reported a severe problem from infertile overwash. The accumulation of sediment in drainage channels was a moderate problem in 15 counties, and severe in 10 counties.

Fifteen counties reported a loss of capacity in ponds, lakes, and reservoirs because of sedimentation.

Fourteen counties indicated that sedimentation was responsible for abnormally high nutrition levels in water bodies.

Twenty counties reported damage to the fish and wildlife resource.

Twenty six miles of Lake Michigan shoreline have a critical erosion problem.

A study of total annual tons of gross erosion in the Basin revealed a two percent contribution from subarea 1, a 16 percent contribution from subarea 2, seven percent from subarea 3, 22 percent from subarea 4, and 53 percent of the total came from subarea 5.

To reduce erosion and sedimentation about 3.8 million acres of cropland; 611,000 acres of pasture and 2.2 million of forest are in need of land treatment measures.

SECTION II

This section consists of responses by county to questions pertinent to local erosion and sedimentation. The questionnaire, prepared for the Great Lakes Basin Study, was originally designed for counties with drainage to one of the Great Lakes. For our Basin report, the same questionnaire was used for the additional eight counties in the Rock River portion of the study area. On occasion a county made no response to a question, or gave multiple answers.

Question 1. Channel erosion (in gullies, waterways and vehicle or livestock tracks) occurs in your county:

(a) 5 rarely or never

Illinois:	None
Michigan:	Menominee County
Wisconsin:	Langlade, Menominee, Milwaukee and Kenosha counties

(b) 26 occasionally to often:

Illinois:	Stephenson and Winnebago counties
Michigan:	Iron and Dickinson counties
Wisconsin:	Forest, Florence, Marinette, Oconto, Shawano, Iowa, Lafayette, Rock, Walworth, Waukesha, Ozaukee, Washington, Manitowoc, Sheboygan, Green Lake, Brown, Door, Waupaca, Outagamie, Waushara, Winnebago and Marquette counties.

(c) 8 often to very frequently:

Illinois:	None
Michigan:	None
Wisconsin:	Fond du Lac, Kewaunee, Calumet, Racine, Dane, Dodge, Green and Jefferson counties.

Question 2. Streambank erosion along the larger streams occurs in your county:

Question 2 continued

(a) 8 rarely or never

Illinois: None
Michigan: None
Wisconsin: Ozaukee, Washington, Florence, Forest, Green Lake, Langlade, Milwaukee and Menominee counties.

(b) 18 occasionally to often

Illinois: None
Michigan: Dickinson, Iron and Menominee counties
Wisconsin: Oconto, Shawano, Waushara, Door, Calumet, Manitowoc, Sheboygan, Waukesha, Walworth, Racine, Kenosha, Kewaunee, Dane, Lafayette and Rock counties.

(c) 13 often to very frequently

Illinois: Stephenson and Winnebago counties
Michigan: None
Wisconsin: Marinette, Outagamie, Waupaca, Marquette, Brown, Dodge, Jefferson, Green, Iowa, Fond du Lac and Rock counties.

(d) Streambank erosion occurs as:

13 occasional scoured spots

Illinois: None
Michigan: Menominee and Dickinson counties
Wisconsin: Forest, Florence, Green Lake, Langlade, Manitowoc, Door, Kenosha, Ozaukee, Racine, Washington and Lafayette counties.

6 frequent scoured spots

Illinois: None
Michigan: Iron County
Wisconsin: Waupaca, Shawano, Calumet, Walworth and Rock counties.

Question 2 (d) continued

11 occasional eroded reaches of channel

Illinois: Stephenson and Winnebago counties
Michigan: None
Wisconsin: Waushara, Oconto, Menominee, Kewaunee, Sheboygan, Racine, Iowa, Jefferson and Lafayette counties.

11 frequent eroded reaches of channel

Illinois: Stephenson County
Michigan: None
Wisconsin: Marinette, Winnebago, Waupaca, Outagamie, Marquette, Brown, Rock, Dodge, Iowa and Green counties.

No Response: Fond du Lac County, Wisconsin.

No Response: Milwaukee County, Wisconsin.

Question 3. Do you consider roadside erosion in your county to be:

(a) 9 a slight problem

Illinois: Winnebago County
Michigan: None
Wisconsin: Forest, Winnebago, Waupaca, Menominee, Langlade, Calumet, Kenosha and Walworth counties.

(b) 28 a moderate problem

Illinois: Stephenson County
Michigan: Dickinson and Menominee counties
Wisconsin: Marinette, Florence, Green Lake, Waushara, Shawano, Outagamie, Oconto, Marquette, Manitowoc, Brown, Calumet, Door, Sheboygan, Milwaukee, Ozaukee, Racine, Washington, Waukesha, Rock, Dodge, Iowa, Dane, Jefferson, Lafayette and Green counties.

Question 3 (c) continued

(c) 4 a severe problem?

Illinois: None
Michigan: Iron County
Wisconsin: Fond du Lac, Kewaunee and Calumet counties.

(d) If there are significant roadside erosion problems in your county, what are the principle causes?: A detailed study has been made of roadside erosion in Wisconsin, so the response to this question was omitted.

Question 4. Do you believe that your county has a significant problem of urban erosion?

Yes - 14

Illinois: Stephenson and Winnebago counties.
Michigan: None
Wisconsin: Dane, Fond du Lac, Jefferson, Kenosha, Kewaunee, Milwaukee, Oconto, Outagamie, Menominee, Racine, Sheboygan, and Waukesha counties.

No - 25

Remaining counties.

(a) The amount of erosion from this source is:

25 negligible to small

Illinois: Winnebago County
Michigan: Menominee, Dickinson and Iron counties.
Wisconsin: Marinette, Forest, Florence, Green Lake, Winnebago, Waushara, Waupaca, Shawano, Calumet, Menominee, Marquette, Langlade, Manitowoc, Calumet, Door, Sheboygan Ozaukee, Walworth, Rock, Iowa and Lafayette counties.

Question 4 (a) continued

11 small to large

Illinois: Stephenson County
Michigan: None
Wisconsin: Fond du Lac, Outagamie, Brown, Kenosha, Racine, Washington, Waukesha, Dodge, Jefferson and Green counties

3 large to very large

Illinois: None
Michigan: None
Wisconsin: Kewaunee, Milwaukee and Dane counties

(b) The current urban development in your county is largely:

18 on nearly level land

Illinois: None
Michigan: Menominee and Iron counties.
Wisconsin: Brown, Door, Iowa, Kenosha, Langlade, Marquette, Manitowoc, Marinette, Milwaukee, Outagamie, Racine, Rock, Waushara, Winnebago, Waupaca and Shawano counties.

19 on sloping land

Illinois: Stephenson and Winnebago counties
Michigan: Dickinson County
Wisconsin: Calumet, Green, Dodge, Dane, Fond du Lac, Florence, Forest, Green Lake, Jefferson, Lafayette, Menominee, Oconto, Ozaukee, Sheboygan, Washington, Waukesha

2 very sloping to steep land

Illinois: None
Michigan: None
Wisconsin: Kewaunee and Walworth counties.

Question 4 (c) continued

(c) How many acres of land in your county do you estimate undergo transition to urban each year?

4 counties - less than 10 acres

Illinois:	None
Michigan:	Iron County
Wisconsin:	Langlade, Marquette, Menominee

11 counties - 10 to 50 acres

Illinois:	None
Michigan:	Dickinson and Menominee counties
Wisconsin:	Calumet, Forest, Fond du Lac, Green, Iowa, Lafayette, Oconto, Marinette, Waupaca and Waushara counties.

8 counties - 50 to 100 acres

Illinois:	None
Michigan:	None
Wisconsin:	Door, Florence, Green Lake, Kewaunee Manitowoc, Rock, Shawano; Walworth

9 counties - 100 to 500 acres

Illinois:	Stephenson County
Michigan:	None
Wisconsin:	Brown, Dodge, Kenosha, Outagamie, Ozaukee, Sheboygan, Washington and Winnebago counties.

7 counties - 500 acres or more

Illinois:	Winnebago County
Michigan:	None
Wisconsin:	Dane, Jefferson, Milwaukee, Oconto, Racine, and Waukesha counties.

Question 5. (a) Do you consider wind erosion in your county to be a

Question 5 continued

11 negligible problem

Illinois:	Stephenson County
Michigan:	None
Wisconsin:	Forest, Florence, Winnebago, Menominee, Brown, Calumet, Ozaukee, Waukesha, Dane and Lafayette counties.

19 slight problem

Illinois:	Winnebago County
Michigan:	Dickinson and Iron counties
Wisconsin:	Marinette, Fond du Lac, Shawano, Langlade, Kewaunee, Door, Sheboygan, Kenosha, Milwaukee, Racine, Walworth, Washington, Green, Rock, Dodge and Iowa counties.

6 moderate problem

Illinois:	None
Michigan:	Menominee County
Wisconsin:	Waupaca, Oconto, Outagamie, Manitowoc and Jefferson counties

3 severe problem

Illinois:	None
Michigan:	None
Wisconsin:	Green Lake, Waushara and Marquette counties

(b) Significant damage from wind erosion comes from:

Blowing on mineral soils - 25 counties

Illinois:	Stephenson and Winnebago counties
Michigan:	Iron, Dickinson and Menominee counties
Wisconsin:	Calumet, Door, Dodge, Green, Green Lake, Iowa, Kewaunee, Kenosha, Langlade, Manitowoc, Marquette, Marinette, Oconto, Outagamie, Racine, Rock, Shawano, Waupaca, Waushara, Walworth.

Question 5(b) continued

Blowing on organic soils - 14 counties

Illinois: None
Michigan: None
Wisconsin: Oconto, Waushara, Marquette, Fond du Lac, Kewaunee, Sheboygan, Washington, Ozaukee, Waukesha, Walworth, Racine, Kenosha, Dane, and Jefferson counties.

From sand dune movement - 3 counties

Illinois: None
Michigan: None
Wisconsin: Brown, Outagamie and Sheboygan counties

Other "Problem of clearing everything for large irrigation equipment" - Waushara County

"Mineral soil blowing across muckland in addition to muck" - Marquette County

"Much fall plowing exposes soil to severe winter wind blowing" - Kewaunee County

No significant damage

Illinois: None
Michigan: None
Wisconsin: Forest, Florence, Lafayette, Menominee, Milwaukee and Winnebago counties.

Question 6. (a) Are there areas in your county that you consider to have unusual sheet erosion problems?

(these are areas that require special effort beyond normally used rotations and mechanical practices in order to reduce sheet erosion rates to acceptable levels.)

Yes - 17 counties

Question 6 (a) continued

Illinois: Winnebago County
Michigan: None
Wisconsin: Outagamie, Waushara, Green Lake, Fond du Lac, Kewaunee, Calumet, Sheboygan, Milwaukee, Walworth, Kenosha, Dodge, Dane, Jefferson, Lafayette, Green and Rock counties.

No - 22 counties

Illinois: Stephenson County
Michigan: Dickinson, Iron and Menominee counties.
Wisconsin: Florence, Forest, Marinette, Langlade, Marquette, Menominee, Oconto, Shawano, Winnebago, Waupaca, Brown, Door, Manitowoc, Ozaukee, Washington, Waukesha, and Iowa counties.

(b) The area(s) exist because of:

No counties reported a soil class with difficult management characteristics.

8 counties - irregular slopes or other topographic factors

Illinois: Stephenson County
Michigan: None
Wisconsin: Calumet, Kewaunee, Kenosha, Racine, Shawano, Sheboygan, and Waukesha counties.

15 counties - type of local farming practice.

Illinois: Stephenson County
Michigan: None
Wisconsin: Green Lake, Fond du Lac, Oconto, Kewaunee, Sheboygan, Kenosha, Milwaukee, Racine, Walworth, Green, Rock, Dodge, Dane and Lafayette counties.

Question 6 (b) continued

2 counties - livestock feeding (large feed lots)

Illinois: None
Michigan: None
Wisconsin: Green and Jefferson counties.

10 counties - other reasons

Illinois:
Michigan:
Wisconsin: Green Lake - "Extensive acreage of peas and sweet corn grown. No residue or cover left after harvest."

Fond du Lac - "Canning companies lease land, and this heavy cash crop has no grass or control measures in rotation."

Iowa - "Heavy corn producing areas have a definite sheet erosion problem - principally because no mechanical or proper management practices are used."

Jefferson - "Beef operations - over population."

Lafayette - "Hog lots on steep slopes."

Kewaunee, Milwaukee and Racine counties -

"Fall plowing," Milwaukee Co. - "Continuous row crop on land owned by speculations waiting to 'develop' this land." Racine County - "Clean tillage practice allowed under feed grain program."

Question 7. Does significant erosion occur from any one or more of the following sources in your county?

Question 7 continued

(a) Scour of bottom land soil from flood flows - 8 counties

Illinois: Winnebago County
Michigan: None
Wisconsin: Brown, Fond du Lac, Outagamie, Sheboygan, Jefferson, Lafayette and Rock counties.

(b) From mine spoil banks - 4 counties

Illinois: None
Michigan: Iron, Dickinson counties
Wisconsin: Washington (gravel pits) and Waukesha (gravel pits)

(c) Shore erosion - 10 counties. (This is exclusive of Lake Michigan.)

Illinois: None
Michigan: None
Wisconsin: Florence, Oconto, Waushara, Winnebago, Marquette, Green Lake, Calumet, Sheboygan, Kenosha, and Dane counties

(d) Other - 11 counties. Briefly describe.

Illinois: Stephenson - increase in row crops with lack of more intensive erosion control practices.
Michigan: Dickinson - mine tailings
Wisconsin: Shawano - no significant erosion
Door - many cropped fields have no rotations
Fond du Lac - sheet, rill and gully erosion
Kewaunee - roadside erosion
Calumet - roadside ditches
Walworth - cash crop farming with no hay and lack of mechanical practices
Dodge - intensive farming - canning crops
Dane - ice on Madison lakes
Green - sheet, gully and streambank erosion

Question 8. (a) Deposition of infertile soil material on flood plain land due to flooding is:

Negligible to slight problem - 31 counties

Illinois: Stephenson and Winnebago counties
Michigan: Dickinson County
Wisconsin: Florence, Forest, Langlade, Marinette, Menominee, Shawano, Waupaca, Outagamie, Waushara, Winnebago, Marquette, Green Lake, Door, Brown, Kewaunee, Calumet, Manitowoc, Ozaukee, Washington, Waukesha, Milwaukee, Racine, Kenosha, Dane, Dodge, Iowa, Jefferson and Rock counties.

Moderate problem - 7 counties

Economic Subarea 1 - Menominee County, Michigan
Economic Subarea 2 - Oconto and Fond du Lac counties, Wisconsin
Economic Subarea 3 - Sheboygan County, Wisconsin
Economic Subarea 4 - Walworth County, Wisconsin
Economic Subarea 5 - Green and Lafayette counties, Wisconsin

Severe problem - 1 county

Economic Subarea 1 - Iron County, Michigan
Economic Subarea 2 - None
Economic Subarea 3 - None
Economic Subarea 4 - None
Economic Subarea 5 - None

(b) Deposition of infertile soil material occurs on:

Less than 10 acres yearly - 18 counties

Illinois: Winnebago County
Michigan: Menominee, Dickinson and Iron counties
Wisconsin: Marinette, Winnebago, Waushara, Menominee, Marquette, Langlade, Kewaunee, Brown, Calumet, Kenosha, Ozaukee, Jefferson, Iowa and Dodge counties.

Question 8 (b) continued

10 to 100 acres yearly - 18 counties

Illinois:	Stephenson County
Michigan:	None
Wisconsin:	Forest, Florence, Green Lake, Waupaca, Shawano, Oconto, Door, Sheboygan, Milwaukee, Racine, Walworth, Washington, Waukesha, Lafayette, Dane, Rock and Green counties.

100 to 500 acres yearly - 3 counties

Illinois:	None
Michigan:	None
Wisconsin	Fond du Lac, Manitowoc and Outagamie counties.

More than 500 acres yearly - no county reported this amount of infertile overwash.

(c) Do you consider soil fertility lost by infertile overwash to be recoverable in:

24 a short time

Illinois:	Winnebago County
Michigan:	Dickinson County
Wisconsin:	Marinette, Forest, Florence, Green Lake, Waushara, Waupaca, Outagamie, Menominee, Marquette, Langlade, Manitowoc, Calumet, Kenosha, Milwaukee, Ozaukee, Racine, Waukesha, Dane, Iowa, Dodge, Rock and Green counties.

10 several years

Illinois:	Stephenson County
Michigan:	Menominee County
Wisconsin:	Fond du Lac, Shawano, Kewaunee, Sheboygan, Walworth, Washington, Lafayette and Jefferson counties.

Question 8 (c) continued

2 a long time

Door and Oconto counties, Wisconsin

1 or never

Iron County, Michigan

No response: Brown and Winnebago counties, Wisconsin

Question 9. (a) Sediment accumulation in drainage channels in your county is slight, moderate or severe problem.

Location	Slight Problem	Moderate Problem	Severe Problem
Subarea 1			
Michigan	Dickinson	Iron Menominee	--
Wisconsin	Forest Florence	Marinette	--
Subarea 2			
Wisconsin	Langlade Menominee Winnebago	Shawano Waupaca Outagamie Marquette	Oconto Waushara Green Lake Fond du Lac
Subarea 3			
Wisconsin	--	Door Brown Manitowoc Sheboygan	Kewaunee Calumet
Subarea 4			
Wisconsin	Washington Ozaukee Waukesha Walworth	Racine	Milwaukee Kenosha
Subarea 5			
Illinois	Stephenson	Winnebago	
Wisconsin	Iowa Lafayette Green	Dane Rock	Dodge Jefferson
Total	14	15	10

Question 9 continued

(b) Channel clean out of sediment is done yearly on:

Less than 10 miles of channel - 30 counties

Economic Subarea 1
Michigan: Dickinson, Iron and Menominee counties
Wisconsin: Florence, Forest and Marinette counties

Economic Subarea 2
Wisconsin: Green Lake, Fond du Lac, Winnebago, Shawano, Outagamie, Menominee, Marquette and Langlade counties.

Economic Subarea 3
Wisconsin: Manitowoc, Brown, Door and Sheboygan counties.

Economic Subarea 4
Wisconsin: Milwaukee, Ozaukee, Racine, Walworth, Washington and Waukesha counties

Economic Subarea 5
Illinois: Stephenson and Winnebago counties
Wisconsin: Green, Rock, Iowa and Lafayette counties.

Ten to 50 miles of channel - 7 counties

Economic Subarea 1 - None

Economic Subarea 2 - Waupaca County, Wisconsin

Economic Subarea 3 - Kewaunee and Calumet counties, Wisconsin

Economic Subarea 4 - Kenosha County, Wisconsin

Economic Subarea 5 - Dodge, Dane and Jefferson counties, Wisconsin

Question 9 (b) continued

More than 50 miles of channel - 1 county

Economic Subarea 1 - None

Economic Subarea 2 - Oconto County, Wisconsin

Economic Subarea 3 - None

Economic Subarea 4 - None

Economic Subarea 5 - None

No response - Economic Subarea 2, Waushara County, Wisconsin.

(c) Estimate the volume of excavation involved in clean-out jobs

Economic Subarea	Percent Less than 5,000 Cu. Yds. of Clean-out Per Mile	Percent 5,000 to 15,000 Cu. Yds. of Clean-out	Percent More than 15,000 Cu. Yds. of Clean-out
Subarea 1			
Iron, Mich.	90	10	-
Dickinson, Mich.	100	-	-
Menominee, Mich.	85	15	-
Forest	100	-	-
Florence	100	-	-
Marinette	95	5	-
Subarea 2			
Langlade	100	-	-
Oconto	50	40	10
Menominee	None	-	-
Shawano	100	-	-
Waupaca	90	10	-
Outagamie	50	30	20
Waushara	No Response		
Winnebago	90	10	-
Marquette	85	15	-
Green Lake	100	-	-
Fond du Lac	Very little, if any		

Question 9 (c) continued

Economic Subarea	Percent Less than 5,000 Cu. Yds. of Clean-out Per Mile	Percent 5,000 to 15,000 Cu. Yds. of Clean-out	Percent More than 15,000 Cu. Yds. of Clean-out
Subarea 3			
Door	90	10	-
Brown	98	2	-
Kewaunee	80	20	-
Calumet	100	-	-
Manitowoc	75	25	-
Sheboygan	25	-	75
Subarea 4			
Washington	100	-	-
Ozaukee	100	-	-
Waukesha	65	25	10
Milwaukee	-	100	-
Walworth	-	100	-
Racine	70	30	-
Kenosha	50	50	-
Subarea 5			
Dodge	40	50	10
Iowa	100	-	-
Dane	80	20	-
Jefferson	-	75	25
Lafayette	100	-	-
Green	100	-	-
Rock	75	20	-
Stephenson, Ill.	100	-	-
Winnebago, Ill.	80	20	-

Question 10. Which of the following sediment damages do you believe occur in your county at significant levels or quantities? (Multiple responses were common.)

(a) Deposition of sediment in storm sewers, on streets, and other urban installations - 10 counties

Illinois: Stephenson and Winnebago counties
Michigan: Dickinson County
Wisconsin: Sheboygan, Waushara, Brown, Milwaukee, Jefferson and Lafayette counties

(b) Unusual water filtration costs due to suspended sediment - 3 counties

Illinois: None
Michigan: None
Wisconsin: Ozaukee, Brown and Washington counties

(c) Muddy or turbid conditions in lakes or ponds used for recreation - 15 counties

Illinois: Stephenson and Winnebago counties
Michigan: Menominee County
Wisconsin: Marquette, Green Lake, Kewaunee, Calumet, Manitowoc, Sheboygan, Washington, Ozaukee, Milwaukee, Dodge, Dane and Rock counties.

(d) Loss of capacity in farm ponds and in larger reservoirs and lakes - 15 counties

Illinois: Stephenson and Winnebago counties
Michigan: Menominee County
Wisconsin: Marinette, Langlade, Oconto, Waupaca, Waushara, Green Lake, Calumet, Sheboygan, Iowa, Jefferson, Lafayette and Rock counties.

(e) Damage to fish and wildlife and their habitat - 20 counties

Illinois: Stephenson and Winnebago counties
Michigan: Dickinson County
Wisconsin: Forest, Marinette, Oconto, Marquette, Green Lake, Brown, Kewaunee, Calumet, Manitowoc, Sheboygan, Milwaukee, Dodge, Dane, Jefferson, Lafayette, Green and Rock counties.

(f) Abnormally high nutrition levels in water bodies from sedimentation - 14 counties

Question 10 continued

Illinois: None
Michigan: None
Wisconsin: Marquette, Brown, Kewaunee, Calumet, Manitowoc, Sheboygan, Milwaukee, Dodge, Iowa, Dane, Jefferson, Lafayette, Green and Rock counties.

Responses to Question 10, sediment damages (g) Other, briefly described, were varied. Answers are compiled below by economic subarea. Some counties made no response.

Economic Subarea 1

Michigan: Iron County - "Mining deposits and stock piles of low grade ore."
Dickinson County - "Deposition of mine tailings most significant damage to land in county."
Wisconsin: Forest County - "Over fertilization from septic effluent is significant on many lakes."

Economic Subarea 2

Wisconsin: Green Lake County - "Deposition of water and wind borne materials in road ditches and natural channels."
Waushara County - "Problem of sedimentation and organic plant remains accumulation in mill ponds have created problem of shallow water areas over mucky bottoms. Destroyed most of recreational values of these water areas. There are nine in the county."
Langlade County - "High nutrition levels in some lakes, ponds and streams from runoff from highly fertilized fields and barnyards."

Economic Subarea 3

Wisconsin: Calumet County - "Sedimentation accumulation in drainage ditches."
Kewaunee County - "Silting of the harbor requiring dredging."

Question 10 continued

Economic Subarea 4

Milwaukee: Milwaukee - "None of the streams in county can be used for swimming and have little value for fishing."

Economic Subarea 5

Wisconsin: Rock County - "Sediment washing off fields filling roadside ditches and covering highways."

Jefferson County - "Not very much sediment in farm ponds."

Additional Information on Erosion and Sedimentation

Question 11. If there is additional information on erosion and sedimentation in your county not covered above, or if you care to elaborate on any of the above questions, please enter here.

Comments from Soil Conservation Service district conservationists are grouped by economic subarea. Some counties made no response.

Economic Subarea 1

Michigan: Dickinson County - "There is some streambank erosion on the Menominee River due to steep, sandy banks. This is true on the Michigamme and others to a limited degree. Most streams have some undercutting of banks and alterations in channel due to this.

Wisconsin: Forest County - "Total roadside erosion - 517,635 sq. ft."

Marinette County - "The main areas of loss in capacity of reservoirs is on the larger rivers where power dams have been built.

Economic Subarea 2

Wisconsin: Oconto County - "The undulating topography makes contouring impossible in this area. The return from a short growing season precludes heavy investments in upland

erosion control practices such as level terraces. With dairying going out and short season cash crops coming in, the sedimentation from cropland area is increasing. With increase in leisure time, more weekend homes, cottages, and so on are being built on all available land. The natural resources and lakes are suffering."

Menominee County - "Erosion is a very minor problem in Menominee County since it is almost all forested except for three active farmers and two villages. There is a new lake development under construction with residential home sites that could be a problem at some future time."

Waushara County - "Stream flooding is insignificant because of many streams originating in the county generally sandy soils. Very little cropland adjacent to streams. Problems occur primarily in east and on silty or clay soil areas and where stream channels flatten out as they approach. Lake Poygan. Delta formation and fanning out of creek mouth at lake or marsh entrance."

Marquette County - "Most of Marquette lakes are man-made (flowages). They are shallow, and exchange of water is slow. These factors complicate the problem and make 10c, e, and f more critical."

Green Lake - "As indicated, wind and water erosion on the prairie soils is of great concern. Demise of dairy farming and conversion to cash grain, peas, or sweet corn with early harvest presents a real problem. This is being worked on by several committees."

Economic Subarea 3

Wisconsin: Kewaunee County - "Recently completed roadside erosion survey reveals: 2,349,740 sq. ft. along town roads;

have a very serious lake bank erosion problem. We also have a serious sewage disposal problem because of our heavy clay soils shallow to bedrock."

Calumet County - "Severe gully erosion in 2 townships of the county."

Manitowoc County - "Sedimentation in town road culvert following reconstruction (widening) of town roads reduces the capacity of culverts by one-fourth first three to four years following construction."

Sheboygan - "In the City of Sheboygan, the harbor of the Sheboygan River has been dredged at least three times in the last 17 years. I have never seen the Sheboygan River flow clear at any time of the year.

"In the future, how will we dispose of the sedimentation in the harbor of the Sheboygan River? Each time it is dredged at least 600,000 cubic yards of eroded soil and debris have been removed from the harbor and deposited several miles out in Lake Michigan.

"If all the land in the watershed of the Sheboygan River could be controlled with the needed erosion control conservation measures, there may not then be a problem. To me this seems to be a very long way into the future of ever being accomplished."

Economic Subarea 4

Wisconsin: Milwaukee County - "The part of harbor that lies in the Menominee River must be dredged annually for navigation. This is the smallest watershed but has the most development. The Milwaukee River

once in every five years and the Kinnickinnic once in every three years (dredging)."

Economic Subarea 5

Wisconsin:

Dodge County - "Intensive farming or cash crop farming along with rolling silt loam soils breed soil erosion. Urban growth is picking up from southeast to compound problem."

Iowa County - "High nutrient levels noted in many farm ponds is probably from run-off from barnyards and feedlots as much as from sedimentation."

Dane County - "Highway and urban erosion around Madison has made it necessary to clean out (dredge) lakes. City engineers have cost figures on this operation.

Jefferson County - "One of the most pressing problems is that of cattle having access to streams, thus causing a great erosion and pollution problem. Another is that of changing enterprise from dairy to say swine, etc., where there is very little or no use for hay. Strips are usually plowed up and continuous row crops on sloping land is the result. We have experienced many urban development problems in which little or no erosion control measures were taken."

Rock County - "The main problem lies with the extensive amount of cash cropping done in Rock County, mainly corn and soybeans, on unprotected slopes."

Illinois:

Stephenson County - "Streambank erosion is a major source of silt in some of our manmade lakes. Our streams and rivers would all be classified as severely

Question 11 continued

meandering. All of them have frequent severe streambank erosion at every sharp channel direction change. When these streams flow through pasture land, as they frequently do, the individual land owner has of necessity placed a low priority on expenditures for control of this type of erosion. He spends his money where he can get the greatest immediate return for the maximum benefit."

BIBLIOGRAPHY

Alden, W.C., 1918, The Quaternary geology of southeastern Wisconsin with a chapter on the older rock formations: USGS, Prof. Paper 106: 356p.

Andrews, Edmund, 1870, The North American lakes considered as chronometers of postglacial time: Chicago Acad. Sci. Trans., vol. 2, p. 7-8.

Ball, J.R., 1971, Shoreland is vulnerable, Wis. Conservation Bulletin. Dept. Nat. Resources, v. 36, No. 4, p. 22-23.

Ball, J.R., and Powers, W.E., 1930, Shore recession in southeastern Wisconsin: Illinois State Acad. Sci. Trans., vol. 22, p. 435-441.

Bates, C.G., and Zeasman, O.R., 1930, Soil erosion a local and national problem: Univ. Wis. Agr. Exp. Sta. Res. Bull. 99, 100 p.

Chamberlin, T.C., 1877, Geology of Wisconsin: vol. 2, p. 231-232.

Cheetham, R.N., Jr., 1970, Control of eroded soil through use of an open drainage system, Esthetic and Technical Innovations in Storm Water Systems Conference, Univ. of Wisconsin, 8 p.

Cheetham. R.N., Jr., 1970, Summary-erosion and sedimentation questionnaire thirty-one Wisconsin counties; U.S.D.A. Soil Conservation Service, Reference Report No. 7, Southeast Wisconsin Rivers Basin, 38 p.

Collier, C.R., 1963, Sediment characteristics of small streams in southern Wisconsin, 1954-59, U.S. Geol. Survey Water Supply Paper 1669-B, iv, B31-34.

Ghormley, G.E., 1956, Allocation of sediment storage for design of floodwater retarding structures (Eng. Memo. No. 9); mimeographed memorandum, U.S. Department of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin, 4 p.

Great Lakes Basin Framework Study, 1971, Appendix 18, Erosion and Sedimentation, Section 6, 236 p.

Guy, H.P., and Jones, D.E., Jr., 1972, Urban Sedimentation in Perspective, Journal of the Hydraulics Division, ASCE, vol. 98, No. HY12, Proc. Paper 9420, p. 2099-2116.

Hansen, E.A., 1971, Sediment in a Michigan trout stream, its source, movement, and some effects on fish habitat, USDA Forest Serv. Res. Paper NC-59, N. Cent. Forest Exp. Sta., St. Paul, Minn., 14 p.

Hays, O.E., McCall, A.G., and Bell, F.G., 1949. Investigations in erosion control and the reclamation of eroded land at the Upper Mississippi Valley Conservation Experiment Station near LaCrosse, Wis., 1933-43. U.S. Dep. Agr. Tech. Bull. 973, 87 p.

Hindall, S.M., and Flint, R.F., 1970, Sediment yields of Wisconsin streams, U.S. Geol. Survey, Hydrologic Investigations, Atlas HA-376.

Horberg, C.L., 1970, Bedrock topography of Illinois, Illinois Bull. 73, State Geol. Survey, 15 p.

Illinois Conservation Needs Committee, 1970, Illinois soil and water conservation needs inventory, U.S. Dept. of Agriculture, Soil Conservation Service, 192 p.

Klingebiel, A.A., and Montgomery, P.H., 1961, Land capability classification, Soil Conservation Service, U.S. Dept. of Agriculture, Agricultural Handbook No. 210, 21 p.

Lull, H.W., and Reinhard, K.G., 1972, Forester. Forests and floods in the Eastern United States. NE. Forest Exp. Sta., Upper Darby, Pa., USDA Forest Serv. Res. Paper NE-226, 94 p.

Marter, J.H. and Cheetham, R.N., Jr., 1971, Areal measurement and nomenclature of watersheds in the southeast Wisconsin Rivers Basin, U.S.D.A., Soil Conservation Service Ref. Report No. 10, Southeast Wisconsin Rivers Basin, 78 p.

Michigan Conservation Needs Committee, 1968, Michigan soil and water conservation needs inventory, U.S. Dept. of Agriculture, Soil Conservation Service, 123 p.

Musgrave, G.W., 1947, The quantitative evaluation of factors in water erosion - a first approximation, Jour. Soil and Water Conservation, v. 2, p. 133-138.

Roadside Stabilization Working Group, 1969, Erosion on Wisconsin roadsides, Univ. Extension, Univ. of Wis., NRCSA, Wisconsin Chapter Soil Conservation Soc. of America, 28 p.

Sartz, R.S., 1963. Water yield and soil loss from soil-block lysimeters planted to small trees and other crops, southwestern Wisconsin. Lake States Forest Expt. Sta., St. Paul, Minn. (U.S. Forest Serv. Res. Paper LS-6) 23 p.

Sartz, R.C., 1970, Effect of land use on the hydrology of small water sheds in southwestern Wisconsin, Pub. 96, Intl. Assn. of Scientific Hydrology, Wellington, N.Z., p. 286-295.

Seaburn, G.E., 1969, Effects of urban development on direct runoff to East Meadow Brook, Nassau County, Long Island, New York, USGS Prof. Paper 627-b.

Task Committee for Preparation for Manual of Sedimentation, 1969, Chapter 5, Sediment control method, introduction and watershed area, Jour. of the Hydraulic Div., ASCE, v. 95, p. 649-675.

Thompson, J.R., 1970, Soil Erosion in the Detroit metropolitan area, Jour., Soil and Water Conservation, v. 25, No. 1, 8 p.

Thorp, E.M., 1972, Sediment transport in alluvial channels, a training guide prepared for SCS engineers and geologists, 18 p.

Upper Mississippi River Comprehensive Basin Study, 1972, v. 3, Appendix G. Fluvial Sediment, p. G1 - G100.

U.S. Dept. of Agriculture (1967 to 1969) Soil Conservation Service, SCS National Engineering Handbook, Section 2, Eng. practice standards, Part 1, Engineering conservation practices.

U.S. Dept. of Agriculture, Soil Conservation Service, 1969, Wisconsin soils - their properties and uses, 216 p.

U.S. Army, Corps of Engineers, 1971, National shoreline study, U.S. Army Engineer Division, North Central, 221 p.

Wark, J.W., and Keller, F.J., 1963, Preliminary study of sediment sources and transport in the Potomas River Basin, U.S. Geol. Survey and Interstate Comm. on Potomac River Basin, 28 p.

Williams, J.R., and Berndt, H.D., 1972, Sediment yield computed with universal equation, Journal of the Hydraulics Division, ASCE, v. 98, No. HY12, Proc. Paper 9426, pp. 2087-2098.

Wisconsin Conservation Needs Committee, 1970, Wisconsin soil and water conservation needs inventory, U.S. Dept. of Agriculture, Soil Conservation Service, 122 p.

Woodruff, N.P., et al, 1969, A study of wind erosion in central Wisconsin, U.S.D.A. Agricultural Research Service, 51 p.

REFERENCE REPORTS PUBLISHED

Reference Report No. 1, A Description of the Agricultural Economy of the Southeast Wisconsin Rivers Basin

Reference Report No. 2, Comparative Methods of Determining Cropland Soil Losses in Iowa County, Wisconsin

Reference Report No. 3, Watersheds and Green Bay Shore Drainage, Brown County, Wisconsin.

Reference Report No. 4, Inventory and Use of Wet Soils Areas in the Wisconsin Portion of the Southeast Wisconsin Rivers Basin

Reference Report No. 5, The Watersheds of Dane County, Wisconsin

Reference Report No. 6, Impact Multipliers for the Economic Evaluation of the Effect of Agricultural Resource Development on Related Sectors of the Economy

Reference Report No. 7, Summary - Erosion and Sedimentation Questionnaire, Thirty-One Wisconsin Counties

Reference Report No. 9, Erosion and Sedimentation, Southeast Wisconsin Rivers Basin

Reference Report No. 10, Areal Measurement and Nomenclature of Watersheds in the Southeast Wisconsin Rivers Basin

Reference Report No. 13, The Economic Base of the Southeast Wisconsin Rivers Basin With Emphasis on the Agricultural Sector

The following studies with unassigned report numbers 8, 11, 12, 14 and 15 were to have been reference reports. Because of constraints and other assignments, the material remains as documentation information in USDA, SCS files.

Predicted Gross Erosion - Waupaca County, Wisconsin
Hydrologic Computer Model of the Pecatonica River Subbasin
Potential Surface Water Storage Inventory, Southeast Wisconsin Rivers Basin
Streambank Erosion Evaluation, Southeast Wisconsin Rivers Basin
Forest Resources in the Southeast Wisconsin Rivers Basin